CHAPTER IV.2: COST OF ASTHMA

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CHAPTER IV.2: COST OF ASTHMA

IV.2.A. BACKGROUND

This chapter contains a discussion of the lifetime incremental direct medical costs incurred by asthma patients, and methods used to estimate those costs. Asthma is of particular concern to EPA because there are many pollutants that may cause or exacerbate this disease. Regulation of primary and toxic air pollutants may result in a reduced number of cases of chronic airway diseases, including asthma. Programs to reduce indoor air pollutants, such as environmental tobacco smoke (ETS), are also crucial in reducing the impacts of this disease. The benefits of such activities can be estimated in part, by evaluating the direct medical costs avoided. A full measure of the costs of asthma would also include direct non-medical costs and indirect costs. This chapter does not include information on elements of willingness-to-pay (WTP), such as indirect medical costs, pain and suffering, lost time of unpaid caregivers, lost productivity of patients, etc. The direct medical costs presented in this chapter may be useful in providing a lower-bound measure of WTP. The reader is referred to Chapter I.1 for a discussion of direct cost estimation methods and cost elements that are relevant to all benefits estimates. In addition, Chapter IV.1 contains general information regarding respiratory illnesses.

The costs presented in this chapter were current in the year the chapter was written. They can be updated using inflation factors accessible by clicking on the sidebar at left.

Link to Chapters I.1 and IV.1
Link to inflation factors

This chapter uses the Guidelines for Diagnosis and Management of Asthma developed by the National Heart, Lung, and Blood Institute (NHLBI, 1997), which provide disease definition and clinical practice guidelines. The guidelines were developed by clinicians and researchers and provide information on current approaches to treating asthma. Current Medicare reimbursements and journal articles were used to obtain cost estimates. The medical and economics literature was consulted to obtain supporting information. A cost estimate was developed for the average patient and an upper bound value was estimated based on patients with moderate or severe asthma who had a high use rate of acute care services.

IV.2.A.1 Description

IV.2.A.1.1 Definition

Asthma is a chronic inflammatory disorder of the airways, designated as ICD9-CM-493 in the International Classification of Diseases (ICD-9).

Airway inflammation contributes to airway hyperresponsiveness, airflow limitation, respiratory symptoms, and the chronic nature of the disease. Airflow limitation and the narrowing of airways can be manifested as acute bronchoconstriction, airway edema, mucus plug formation, and remodeling of the airway walls. In susceptible individuals, this inflammation causes recurrent episodes of wheezing, breathlessness, chest tightness, and coughing. Asthma patients are usually categorized as having mild persistent, mild intermittent, moderate persistent, or severe persistent asthma, based on symptoms and the results of diagnostic tests. Their care depends, to some extent, on this categorization (NHLBI, 1997). Asthma episodes (also referred to as exacerbations or acute symptoms) are periods when bronchial constriction restricts airflow and causes the symptoms described above. The episodes can be triggered by allergens, irritants such as cigarette smoke, odors, pollution, sulfite preservatives, weather changes, and emotions. Prolonged severe attacks may be precipitated by common colds (e.g., influenza, rhinovirus). Some drugs cause short severe attacks (e.g., aspirin, nonsteroidal anti-inflammatory drugs). Responses are typically triggered within a few hours and may persist as a hypersensitive response to stimuli for two to three weeks (Eggleston, 1994).

In recent years the importance of inflammation in asthma has been further substantiated by research. When inflammation occurs, it is usually associated with airflow obstruction that is often reversible spontaneously or with treatment. The inflammation also causes an increase in the existing bronchial hyperresponsiveness to the triggers listed above. At the physiological level, asthma results from complex interactions among inflammatory cells, mediators, and other cells and tissues in the airways (NHLBI, 1997).

Although asthma may affect individuals throughout their life, the disease has certain age-specific characteristics and differential diagnosis issues. These issues need to be considered in the etiology and treatment of asthma (NHLBI, 1997). This chapter focuses on asthma that is diagnosed in childhood because that is the most common period of diagnosis, and much of the care provided for asthmatics is provided during childhood. In addition, the Agency has a particular interest in costs associated with childhood asthma. Most of the information provided is relevant to patients of any age, however, and information is provided to allow the reader to calculate costs associated with asthma onset at any age.

Asthma is a leading cause of morbidity among children and is the most commonly cited reason for school absenteeism, accounting for one-third of all school days lost. It is the most common cause for hospitalization of children. The median age of onset of asthma is four years; however, more than 20 percent of children who are diagnosed with asthma develop symptoms during the first year of life (Eggleston, 1994).

IV.2.A.1.2 Sources of Health Statistics Data

Although asthma is one of the most common chronic diseases in the U.S. and has increased in importance over the past 20 years, surveillance of asthma trends was very limited until recently. CDC provided summary data in 1998 for the overall period 1960 to 1995 that described some of the trends in asthma occurrence (CDC, 1998a). These data include asthma prevalence(for the years 1980-1994).[1] They also include asthma office visits (1975-1995), emergency room visits (1992-1995), hospitalizations (1979-1984), and deaths (1960-1995). The CDC report noted that the overall trend has been toward an increase in asthma prevalence and asthma deaths, with substantial differences in death rates within a single geographic region. Asthma hospitalizations have increased in some areas and decreased in others. Surveillance data are not available at the state or local levels, with the exception of asthma mortality (CDC, 1998a).

The National Center for Health Statistics (NCHS) collected much of the basic information on which the 1998 CDC surveillance summary was based (CDC, 1998a). They used the National Health Interview Survey which provides data on prevalence supplied by patients.[2] They also used the National Ambulatory Medical Care Survey which provides physician office visit data; the National Hospital Ambulatory Medical Care Survey, which provides emergency room visit data; and the National Hospital Discharge Survey, which provides data on in-hospital stays. Mortality data were also collected from each state (CDC, 1998a). Information is expressed both as the absolute value (e.g., number of cases) and the rate in the population (e.g., 2 per 10,000 people).[3] Age groupings used in the CDC surveillance summary are 0 to 4, 5 to 14, 15 to 34, 35 to 64, and >64 years (CDC, 1998a).

Mortality data from CDC (1998a) were limited, so additional information was also obtained from NCHS's FASTATS (CDC, 1999a). Multiple areas within this large database were used; they can be accessed through the website listed in the References section.

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[1] Prevalence is a measure of how many people have a disease, rather than how many were newly diagnosed in a particular year.

[2] The prevalence of a chronic disease is often determined through patient surveys.

[3] It is useful to consider both values because neither value alone can fully express trends and potential impacts. Rates provide information on changes, standardized to a specific size population. Absolute values reflect a combination of changes in the rate, along with changes in the underlying population size. For example, a rate could stay the same, but if the population increased by 20 percent, then the absolute number of cases would need to increase by 20 percent to maintain the same rate.

CDC also published a forecast estimate of self-reported asthma prevalence for the U.S. in 1998 (CDC, 1998b). This estimate was developed using 1995 survey data, 1998 census data, and linear extrapolations of region-specific increases in asthma prevalence over previous years (CDC, 1998b).

Another report by CDC contains an evaluation of the number and rate of ambulatory care visits for various diagnostic categories for the period 1993 to 1995 for children under 15 years of age (CDC, 1998c). The National Hospital Ambulatory Medical Care Survey provided hospital outpatient data used in this analysis. There are age restrictions in the data (only ages 0 to 14 are covered); however, other data sources were not located for hospital outpatient visits. The survey data are therefore used both as the source of the rate for those patients aged 0 to 14, and to estimate the visits for patients 15 years and older.

Data from the various government statistical summaries are provided below. In addition, some statistics are calculated using existing data. Most calculated statistics are for 1994 because this is the most current year for which prevalence data are available. Prevalence is important because it is a commonly used denominator in calculating statistics in this analysis, such as the rates of various services per asthmatic.

An important consideration when reviewing the asthma statistics is the way the rates are presented. Data on rates are provided in the CDC reports using the entire general population in the group of interest as a denominator (e.g., all people, all people aged zero to four, all blacks, etc). This division gives a somewhat distorted sense of the utilization of services by asthmatics because both the prevalence of asthma in the population and the size of the overall population have increased. The rate of service use could therefore appear to increase in the general population, while it actually decreased *among asthma patients.* Consequently, many statistics are presented using two types of rates for this discussion:

- rate per number in the population — denominator is total number of people in group of interest (e.g., children aged zero to four), and

- rate per number of asthmatics — denominator is number of asthmatics in the group of interest.

The rates are important because they are used to estimate the proportion of asthmatics using various services in the cost section of this chapter, which follows. Because the rates are not generally provided in the CDC reports, most rates *per asthmatic* were calculated for this analysis using the CDC statistics.

IV.2.A.1.3 Prevalence of Asthma

The self-reported prevalence of asthma increased 75 percent from 1980 to 1994 to 13.7 million people during the period from 1993 to 1994, and the trend was observed among all races, sexes, and age groups (CDC, 1998a). Estimates of asthma prevalence in 1998 by CDC, based on population trends and the pattern of increasing incidence, yielded a CDC-estimated total of 17,229,000 asthmatics of all ages in the U.S. (CDC, 1998b). This section focuses on the actual reported values (CDC, 1998a), rather than on the estimated prevalence (CDC, 1998b).

The increase in asthma prevalence was the greatest for children aged 0 to 4 (160 percent) with a rate increase during the period 1980 to 1994 from 22.2 per 1,000 (2.2 percent) to 57.8 per 1,000 (5.8 percent).[4] The current rate indicates that more than 1 in every 20 very young children have asthma, with approximately 1.3 million children in this age group having asthma during the most recent survey period (1993-4), in contrast with 360,000 in 1980 (CDC, 1998a). As noted above, the average age of diagnosis is four years, so half of all children will be diagnosed with asthma after the age of four. There was a 74 percent increase in prevalence in the age group 5 to 14 from 1980 to 1994. By the age of 18, the prevalence is 7.5 percent. This is in contrasts to the general population (all ages), with a prevalence of 5.7 percent. The prevalence rates are near or below 5 percent among age groups over 18 (CDC, 1998b). Among adults 35 years and older, the asthma rate was 44.6 per 1,000 (4.5 percent) in 1993-4. Asthma prevalence is 14 percent higher among blacks than whites, with rates of 57.8 versus 50.8 per 1,000 (5.8 versus 5.1 percent) during the most recent survey period (CDC, 1998a).

Asthma is most commonly diagnosed in children by the age of five and in adults in their thirties, although onset of symptoms can occur at any age. About ten percent of patients are first diagnosed with asthma after age 64 (AAFA, 1999).

Family income is related to asthma incidence, with those under the age of 45 having a prevalence of eight percent when family incomes were less than $10,000 compared to six percent for those with incomes greater than $35,000 (CDC, 1999a).[5]

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[4] All rates are expressed in terms of the entire population rather than just asthma patients, unless otherwise stated. For example, 10 per 1,000 indicates 10 cases among all the population, of whom some are asthma patients. This standard is used for all rates expressed in this section, unless otherwise noted.

[5] NCHS does not provide much detail on the age group of most interest to this analysis in their summary statistics (they group all those under the age of 45 together for many statistics). Consequently, the data are reported for this group, although those under 18 are of most interest.

Many studies have reported an association between urban residence and asthma. The NCHS aggregate statistics (not provided by individual age group) support this association, with a rate of 5.8 percent in metropolitan statistical areas compared with 5.1 percent in non-metropolitan areas. The rate is slightly higher in central city areas compared to non-central city areas within a metropolitan area (CDC, 1999a). Some areas have reported much higher rates, including Chicago, Bronx, and an area in Louisiana (CDC, 1998b).

There is substantial variation in asthma rates among states, although data are limited. In three states where surveys of adults were recently carried out, self-reported medically diagnosed active asthma in the previous year occurred in 6.6 percent and 7.4 percent of the population in Oregon in the years 1995 and 1996 respectively. Of those, 9 percent received emergency care for asthma in the preceding year. In New Hampshire, 11 percent of respondents reported having medically-diagnosed active asthma, and 19.9 percent of males and 44.6 percent of females had used medication (CDC,1998a). In Washington state, 10.8 percent of adults reported having asthma at some point in their life and 12.8 percent of children had asthma. Family incomes below $20,000 per year were associated with an approximately two-fold increase in asthma prevalence among children (MMWR, 1999). More state data will be available in the future, allowing national patterns to be evaluated.

IV.2.A.1.4 Office Visits

Use of office visits has increased in approximate correspondence to the prevalence of asthma. From 1975 to 1995, the estimated annual number of office visits for asthma increased from 4.6 to 10.4 million. The lowest rate of office visits was among people aged 15 to 34 years. The annual rate of office visits for asthma during the period 1993 to 1995 was 39.6 for whites and 43.8 for blacks per 1,000. The rate was higher for pediatric cases: 50.3 for ages 0 to 4 and 51.5 for ages 5 to 14 (CDC, 1998a).

The rates of office visits *among asthmatics* was calculated for this analysis using the prevalence statistics and the number of office visits reported by CDC (1998a). In 1994 there were 1,024,000 office visits for asthma among children aged 0 to 4 and a population of 1,300,000 children aged 0 to 4 with asthma. These statistics yield a rate of 780 per 1,000 asthmatic children for age 0 to 4, yielding an average annual office visit rate of 0.78 per patient. Using the same calculation for the age group 5 to 14, the rate was 720 per 1,000, yielding an annual average visit rate of 0.72 per patient.

As with all services discussed in this section (e.g., hospitalization, emergency room use), it was not possible to determine what percentage of patients had more than one office visit more in a year, nor the distribution of visits among patients. However, it was possible to estimate the average number of visits per patient (CDC,1998a). For costing purposes, the rates

make it possible to calculate an average cost per patient, even though some patients will have much higher or lower costs, depending on actual utilization of medical services.

IV.2.A.1.5 Hospital Outpatient Visits

There is a trend toward increasing provision of outpatient services by hospitals. These may function as clinics, or be more similar in practice to a group medical practice within a hospital. These outpatient visits provide the same kind of care that is provided in a physician's office; it is therefore anticipated that the costs will be the same (discussed in Section IV.2.B, below). It is important to determine the number of these visits that occur annually, to estimate the total number of medical visits and to determine the number of visits per year by a patient.

The CDC report "Ambulatory Health Care Visits by Children: Principal Diagnosis and Place of Visit" provides information on the number of children and rate per 100 children for ambulatory visits to physicians' offices, hospital outpatient departments, and emergency rooms (CDC, 1998c). Other sources of information for physicians' visits and emergency room visits are preferable for most statistics because they cover all ages, while this report covers patients only up to age 14. This report is useful, however, for evaluating patient utilization of hospital outpatient services, which the other sources do not describe.

CDC (1998c) reports an outpatient visit rate of 0.8 per 100 children aged 0 to 14 per year, during the 1993 to 1995 period, with 469,000 visits per year. Dividing the number of visits by the total number of asthmatic children in this age group of 4,090,000 children yields an average annual visit rate of 0.115 per asthmatic child. To evaluate the use of outpatient hospital care among those over 14 years of age, it was assumed that the relationship between this type of care and physician's office visits would be the same across ages. The ratio of hospital outpatient visits to office visits among children aged 5 to 14 is 0.115/0.72 = 0.159. The rate of office visits among all asthmatics in 1994 was estimated to be 0.607 per year (including adults and children). By applying the outpatient/office visit ratio determined for children (0.159) to the office visit rate for all ages (0.607), the rate of outpatient use per patient can be estimated as: $0.159 \times 0.607 = 0.10$.

IV.2.A.1.6 Combined Medical Visit Rate

When the hospital outpatient visit rate is added to the office visit rate, the total annual physician visits per patient can be estimated. As described above, the per patient rate of office visits among all asthmatics in 1994 was estimated to be 0.607 per year and the rate of outpatient use was estimated to be 0.10. Summing these two values yields an overall patient visit rate of 0.707 for the average patient. In subsequent discussions, the outpatient and physicians' office visits are discussed together as physician's office

visits, due to their similarity and to the fact that a physician is usually seen in either location.

An estimate of the medical visit rate for children can also be calculated. CDC (1998c) reports a physician visit rate of 5.3 per 100 children (similar to that reported in CDC 1998a), with 3,029,000 visits per year. Combining the hospital outpatient visits with the office visits yields 3,498,000 visits per year. This total yields an overall rate of 0.855 per patient aged 0 to 14 (2,498,0000/4,090,000). An annual visit rate can be calculated for the two childhood age divisions. For zero- to four-year-olds, the office visit rate listed above was 0.78 per patient. Adding the rate of 0.115 from above yields 0.895 per year. For five- to fourteen-year-olds, the office visit rate of 0.72 per patient was combined with the rate of 0.115 to obtain a rate of 83.5 per patient (taken directly from or calculated from statistics provided in CDC, 1998a).

IV.2.A.1.7 Emergency Room Use

Only recent data (1992-1995) are available on emergency room use, so longitudinal trend analysis is limited.[6] In 1994 the overall rate was 6.3 per 1,000 and 0.117 per asthmatic. There was not a statistically significant change in use over the four-year period among all patients (CDC, 1998a), but the rate of use by black asthmatics increased by 50.1 percent. Among white asthmatics the increase was 4.1 percent (calculated from statistics provided in CDC, 1998a and CDC, 1998c). Blacks had consistently higher rates of use than whites with a rate in 1995 (the most recent year with data) of 22.9 per 1,000 (population) versus 4.9 in whites. In 1994, the likelihood of an asthma patient visiting an emergency room was 0.337 for blacks and 0.087 for whites (taken directly from or calculated from statistics provided in CDC, 1998a).

Rates were higher for younger than for older patients. In 1994, the rate for children aged 0 to 4 was 14.5 per 1,000 people. For ages 5 to 14 the rate was 8.0 per 1,000 people. Rates of emergency room use in 1994 *among asthmatic children* were 239 per 1,000 (23.9 percent) for ages 0 to 4, and 112 per 1,000 (11.2 percent) for ages 5 to 14. Rates per 1,000 in the general population were very similar among the age groups within the span from 15 to 64 (approximately 7 per 1,000) and much lower for the elderly (65+ years) at 3.0 per 1,000. Rates *among asthmatics* in those age groups were lower than the rates for children (taken directly from or calculated from statistics provided in CDC, 1998a).

As discussed above under office visits, it was not possible to determine what percentage of patients used an emergency room more than once in a given year, so the values provided are an average across all patients. As

[6] Use is defined by CDC as admission for asthma listed as first diagnosis.

discussed in Section IV.2.B below, some patients have a much higher rate of emergency room use and hospitalization than the average patient.

IV.2.A.1.8 Hospitalization

Asthma is the ninth leading cause of hospitalization nationally (CDC, 1998b). Although the number of hospitalizations has increased substantially during the period 1980 to 1994 from 386,000 to 466,000, the rate of hospitalizations has not changed significantly (17.6 to 18.1 per 10,000 people). When the increase in asthma prevalence is considered, the hospitalization rate *among asthma patients* has actually decreased over the years considered. The hospitalization rate among asthmatics in 1994 was 0.034 per patient (calculated from data on prevalence and hospitalization provided in CDC, 1998a)

There have been dramatic shifts in hospitalization usage by whites and blacks during the period of study (1980 to 1994). While overall hospitalization rates for asthma patients have decreased by approximately 25 percent during that period, hospitalization among blacks has increased by 37 percent from 26.0 to 35.5 per 10,000. During the most recent observation period (1994) blacks had a hospitalization rate that was more than three times greater than whites, even though blacks have only a 14 percent greater prevalence of the disease (see prevalence discussion above) (CDC,1998a).

Hospitalization of patients of different ages has also changed during the observation period. Hospitalization of patients aged 35 and older has declined, but the number (not rate) of hospitalizations of very young children has increased dramatically. Among zero- to four-year-olds there has been a 45 percent increase in the hospitalization rate, from 34.3 to 49,7 per 10,000. This rate should be compared with an overall rate increase in the prevalence of asthma among this age group (discussed above) of 160 percent, which is substantially greater than the rate of hospitalization. (The total number of children in this age group with the disease in 1980 was 360,000 versus 1,280,000 in 1994). Using these numbers with the number of hospitalizations in 1980 (56,000) and 1994 (97,000), the hospitalization rates were estimated. In 1980, the rate of hospitalization among young asthma patients was approximately 16 percent, and in 1994 it was approximately 8 percent.[7] The hospitalization rate *among asthma patients* in this age group is therefore approximately one-half of what it was in 1980 (taken directly from or calculated from statistics provided in CDC, 1998a).

There has been a very modest increase among older children and young adults in the hospitalization rate per 10,000 people. For ages 5 to 14, the

[7] There is no way to determine which patients were hospitalized more than once in a given year, but these overlaps are not expected to occur more frequently in 1994 than in 1980. Due to this uncertainty, the percents provided are approximate values.

increase has been from 15.9 to 18.0 per 10,000; for the age group 15 to 34, the increase has been from 8.7 to 10.0 per 10,000 (taken directly from or calculated from statistics provided in CDC, 1998a). As with very young children discussed above, the overall asthma hospitalization rate *among asthma patients* in this age group has declined substantially.

Evaluating the reasons behind trends observed in hospitalization of asthma patients is difficult because many factors impact hospitalization, including:

- changes in the health status of patients (e.g., severity of the disease, management of the disease),
- changes in guidelines for admission to hospitals due to managed care,
- cost containment efforts or other considerations,
- a shift to emergency room use without admission rather than admitting patients,
- patient preferences,
- more self-administered therapy, or
- other factors.

The reduction in hospitalizations should *not* be interpreted as an improvement in the health status of patients, without additional information on the causes of the decreases in admissions.

There are regional differences in hospitalization; however, these are not discussed in this analysis. The differences may be reviewed in the summary provided by CDC (CDC,1998a)

IV.2.A.1.9 Mortality

Mortality from asthma is relatively rare and directly impacts the medical costs only by reducing the medical costs for those patients who die. Mortality is a sentinel event, however, as infant mortality is, in expressing the overall health or sickness of a population or population subgroup. Mortality is usually preceded by considerable medical treatment for illness (although not in every case for asthma). As such, it is useful to evaluate the patterns of mortality to gain some insight into medical care. Because mortality has little direct effect on the cost of medical care for asthma, limited data are provided below.

The CDC has provided a summary of mortality numbers and rates, by five-year increments over the past two decades (CDC, 1998a). They note that changes in the ICD codes and diagnosis during that period complicate the analysis of trends (CDC,1998a). Asthma-related deaths vary considerably by age group, with 85 percent of deaths occurring among people over 34 years of age. This rate may be due to the overlap of asthma with chronic

obstructive pulmonary disease (COPD), which usually occurs in older individuals. Decreases in airway function, which is reversible in asthma, is not reversible with COPD (CDC,1998a).

During the 1993 to 1995 observation period, the annual death rate from asthma was 17.9 per 1,000,000 population (CDC, 1999b). Using the total asthma population of 13,690,000, and 5,429 deaths (both from 1994), the death rate *among asthmatics* was 397 per 1,000,000 (an annual probability of dying of 0.0004). Among whites the mortality rate was 15.1 per 1,000,000 general population; among blacks the rate was 38.5 per 1,000,000 general population (CDC, 1999b). In light of the fact that the prevalence rate of asthma among blacks and whites is very similar (50.8 versus 57.8 per 1,000 general population, respectively (CDC, 1998a)), the difference in death rates is striking.

In addition to the source used above, CDC also provides a more detailed age-, race-, and sex-specific summary of mortality related to asthma, as well as other diseases (CDC, 1999b). These data can be used to determine the age- and race-specific mortality rates. There is no rate listed (numbers are too small to estimate reliably) for the first year of life. For ages 1 to 4 and 5 to 9, the rate is 0.2 per 100,000 general population. For ages 10 to 14 and 15 to 19, the rate is 0.4 per 100,000. The rate very gradually increases as age increases for subsequent ages (taken directly from or calculated from statistics provided in CDC, 1998a).

There are clear racial differences in deaths due to asthma among children. Among blacks, the numbers are too small to estimate reliably under age five. From that age forward, the rates are substantially higher than for whites. The black/white ratio for children is as follows:

Age	Black Rate/White Rate
5 to 9	0.8 per thousand / too small to estimate
10 to 14	1.2 / 0.2 = 6-fold difference
15 to 19	1.0 / 0.3 = >3-fold difference

The differences in mortality persist through adulthood. The overall mortality rate due to asthma is 3.86×10 (-4) among whites and 6.31×10 (-4) among blacks with asthma.

A number of studies have evaluated differences in medical care, hospitalization, emergency room use, and mortality between blacks and whites. A discussion of the hypotheses offered for these differences is beyond the scope of this chapter, which is focused on direct medical costs. One frequently offered observation is that better patient outreach and education reduces severe episodes and resulting emergency room visits and

hospitalizations by improving control of the disease. This improvement is likely to have an impact on mortality. (A subset of these patients is discussed below as "high-use" patients).

IV.2.A.1.10 Summary of Asthma Statistics

Table IV.2-1 contains information on prevalence and some aspects of medical care for asthma. Most notable statistics in the table were discussed in preceding sections. Statistics that are used later in cost calculations are bolded with an * at the beginning of the entry.

Table IV.2-1: Asthma Statistics: Data on overall population statistics, age, and racial characteristics [a, b, c, d]

Characteristic	Statistic	Source
Prevalence		
number 1994	13,700,000	CDC, 1998a
number forecast 1998	17,200,000	CDC, 1998b
number of blacks 1994	1,880,000	CDC, 1998a
number of whites, 1994	10,700,000	CDC, 1998a
overall rate per 1,000	57 (5.7%)	CDC, 1998a
overall rate under 18 years per 1,000	75 (7.5%)	CDC, 1998a
number of children aged 0 to 4 in 1980	360,000	CDC, 1998a
number of children aged 0 to 4 in 1994	1,300,000	CDC, 1998a
rate for ages 0 to 4 per 1,000 in 1980	22.2 (2.2%)	CDC, 1998a
rate for ages 0 to 4 per 1,000 in 1994	57.8 (5.8%)	CDC, 1998a
increase in prevalence rate in children 0 to 4 from 1980 to 1994	160%	Calculated from statistics provided in CDC, 1998a
number of children aged 5 to 14 in 1980	1,520,000	CDC, 1998a
number of children aged 5 to 14 in 1994	2,790,000	CDC, 1998a
increase in prevalence rate in children 5 to 14 from 1980 to 1994	74%	Calculated from statistics provided in CDC, 1998a
Office Visits [e]		
rate 1994 all ages per 1,000	34.1	CDC, 1998a
rate 1994 per asthmatic patient	0.607	Calculated from statistics provided in CDC, 1998a
rate 1994 ages 0 to 4 per 1,000	50.3	CDC, 1998a
rate 1994 per asthmatic patient	0.78	Calculated from statistics provided in CDC, 1998a
rate 1994 ages 5 to 14 per 1,000	51.5	CDC, 1998a
rate 1994 ages 5 to 14 per asthmatic patient	0.72	Calculated from statistics provided in CDC, 1998a
rate 1994 among blacks per 1,000	43.8	CDC, 1998a
rate 1994 among whites per 1,000	39.6	CDC, 1998a

Table IV.2-1: Asthma Statistics: Data on overall population statistics, age, and racial characteristics [a, b, c, d]

Characteristic	Statistic	Source
Outpatient Hospital Visits		
rate 1994 among children aged 0 to 14 per 100 children	0.8	CDC, 1998c
rate 1994 among children aged 0 -14 per asthmatic child	0.115	Calculated from data provided in CDC, 1998c and 1998a
rate 1994 extrapolated to patients over age 14 (see text for method)	0.10	Calculated from data provided in CDC, 1998c and 1998a
Combined Office/Outpatient Visits		
rate 1994 for children 0 to 4 per asthmatic patient	**0.855**	**Calculated from data provided in CDC, 1998c and 1998a**
***rate 1994 extrapolated to all asthmatics expressed per asthmatic patient (see text for method)**	**0.707**	**Calculated from data provided in CDC, 1998c and 1998a**
Emergency Room (ER) Visits (no historical data were available) [f]		
rate 1994 all ages per 1,000	6.3	CDC, 1998a
***rate 1994 of ER visits per asthmatic**	**0.117**	**Calculated from data provided in CDC, 1998c and 1998a**
rate 1994 ages 0 to 4 per 1,000	14.5	CDC, 1998a
rate 1994 ages 5 to 14 per 1,000	8.0	CDC, 1998a
rate 1994 among blacks per 1,000	19.1	CDC, 1998a
rate 1994 among whites per 1,000	4.6	CDC, 1998a
rate of admissions among black asthmatics 1994 (635,000 admissions per 1,880,000 cases)	0.337	Calculated from statistics provided in CDC, 1998a
rate of admissions among white asthmatics 1994 (927,000 admissions per 10,700,000 cases)	0.087	Calculated from statistics provided in CDC, 1998a
increase in rate among blacks during period 1992 to 1995 (4 years) per 1,000 general population (228.9 in 1995/151.9 in 1992) [h]	50.1%	Calculated from statistics provided in CDC, 1998a
increase in rate among whites during period 1992 to 1995 (4 years) per 1,000 general population (48.8 in 1995 versus 46.8 in 1992)	4.2%	Calculated from statistics provided in CDC, 1998a
Hospitalization (described as number of discharges) [g]		
number 1980	386,000	CDC, 1998a
number 1994	466,000	CDC, 1998a

Table IV.2-1: Asthma Statistics: Data on overall population statistics, age, and racial characteristics [a, b, c, d]

Characteristic	Statistic	Source
rate per 1,000 in 1980	1.76	CDC, 1998a
rate per 1,000 in 1994	1.81	CDC, 1998a
***rate of hospitalization among asthmatics all ages in 1994**	**3.4%**	**Calculated from statistics provided in CDC, 1998a**
change in rate per asthma patient for all patients	-25%	Calculated from statistics provided in CDC, 1998a
rate of hospitalization among asthmatic children aged 0 to 4 in 1980	16%	Calculated from statistics provided in CDC, 1998a
rate of hospitalization among asthmatic children aged 0 to 4 in 1994	8%	Calculated from statistics provided in CDC, 1998a
change in rate among asthmatic children aged 0 to 4 from 1980 to 1994	-50%	Calculated from statistics provided in CDC, 1998a
change in rate per 10,000 for children aged 0 to 4 from 1980 to 1994	+45%	Calculated from statistics provided in CDC, 1998a
change in rate per 1,000 for blacks from 1980 to 1994	+37%	Calculated from statistics provided in CDC, 1998a
Mortality		
rate 1994 per 1,000 general population	0.0179	CDC, 1999b
rate 1994 among asthmatics per patient	0.0004	Calculated from data provided in CDC, 1998a
rate 1994 among whites per 1000	0.0151	CDC, 1999b
rate 1994 among blacks per 1,000	0.0385	CDC, 1999b
rate 1994 among asthmatic blacks per patient	$6.31 \times 10^{(-4)}$	Calculated from data provided in CDC, 1998a and 1999b
rate 1994 among asthmatic whites per patient	$3.86 \times 10^{(-4)}$	Calculated from data provided in CDC, 1998a and 1999b

Table IV.2-1: Asthma Statistics: Data on overall population statistics, age, and racial characteristics [a, b, c, d]

Characteristic	Statistic	Source

a. All numbers and rates are annual. See text for additional detail.

b. All rates are per person in the general population unless otherwise noted. When rates are expressed per asthmatic, the number of asthmatics is the 1993-4 value, unless otherwise noted.

c. The study period 1993-1994 is listed as 1994, while the study period 1979-1980 is listed as 1980.

d. Age- and race-related statistics are presented only when there are differences across the ages or races. If the values are very similar (e.g., as with overall prevalence of the disease among whites and blacks), no data are listed. Data are not provided on the racial designation "other," which comprises a very small portion of asthmatic patients and represents a diverse group of individuals who are categorized as neither black or white (e.g., Hispanic, Native American, Asian).

e. It was not possible to determine the percentage of patients with more than one office visit per year. The statistics presented do not indicate the total number of persons treated, but rather the number of visits that occurred.

f. It was not possible to determine the percentage of patients with more than one visit to the ER. The statistics presented do not indicate the total number of persons treated, but rather the number of visits that occurred.

g. It is important to note the differences in rates when expressed per population versus per asthmatic patient. The overall number of asthmatic patients has increased substantially, as well as the rate of asthma in the population. Increases in use of services (e.g., office visits, ER visits, hospitalizations) must therefore be considered in light of the number of asthmatics, rather than just the overall population.

h. The percentage change is calculated as: $\{ (y2 - y1)/y1\} \times 100$, where y1 = the number in earlier years and y2 = the number in the most current year considered.

* Statistics that are bolded (but not italicized) with an * are used in calculating costs later in this chapter.

IV.2.A.1.11 Variations in the Management and Use of Medical Services Among Asthmatic Patients.

Variations in disease management and the use of medical services occur on the basis of individual patient characteristics, including the severity of the disease. Considerable variation also results from the degree to which a patient has, and follows, an adequate asthma management plan. Under optimal circumstances, most patients would have a long-term asthma management plan that managed the symptoms of asthma sufficiently well that they did not have asthma episodes requiring medical intervention in emergency rooms or as inpatients in hospitals. Theoretically, the management plan would control inflammation sufficiently well with long-acting therapies so that short-acting therapies in response to airway restrictions were not routinely required. NHLBI has issued guidelines designed to address this issue. In practice, many patients either do not receive drug plans, or do not follow drug plans that manage asthma at this level of control.

Considerable evidence supports the contention that many, if not most, patients do not receive or follow treatment plans that are consistent with NHLBI guidelines, although the degree of compliance varies. Recent studies suggest that many patients who are seen in emergency rooms report not having treatment plans or not taking anti-inflammatory medication on a regular (proactive) basis. It has also been estimated that over one half of all people who use inhalers do not use them properly (AAFA, 1999).

It has been suggested, anecdotally, that it will take some time for NHLBI guidelines to become familiar and comfortable to most primary care physicians. In addition, there is not consensus among all physicians that they should prescribe according to NHLBI guidelines. Another factor is constraints on medical providers' time for patient education (due to cost containment or other reasons). This factor may be an important contributor to the seemingly high percentage of patients who do not use drug therapies that are optimal. Patients may also resist or not remember treatment plans. Regardless of the reasons behind the noncompliance with NHLBI guidelines, the fact of its occurrence is a reality. This noncompliance poses problems in evaluating both treatment of and costs for asthma.

One approach to this problem is to evaluate the studies that have been done on patients before and after training in optimal asthma management. Such an evaluation can provide information that can be used to estimate variations in management and services that occur and their costs. Studies of educational interventions have focused mainly on populations that have had a high level of acute care (e.g., emergency room use or hospitalization) in the recent past. Although these populations are not representative of the cross-section of asthma patients, the studies provide insight into both 1) the

high level of costs incurred by some patients, and 2) the savings in medical services and costs that may be gained through patient compliance with asthma management plans.

It has been estimated that the costs of hospitalizations and emergency room (ER) visits for asthma together comprise about 73 percent of the total direct expenditures on asthma for children (age 17 and under) in the United States (Weiss et al., 1992). It is also generally believed that most hospitalizations and ER visits for asthma could be avoided by following an asthma management protocol, such as NHLBI guidelines (see, for example, Weiss et al., 1992; Coventry et al., 1996; and Higgins et al., 1998). Although there are no national statistics on the costs of asthma for those asthmatics who do *not* follow such guidelines, several studies of the cost savings resulting from asthma management education programs support the hypothesis that the asthma-related medical costs for those asthmatics who do not follow an asthma management protocol are likely to be substantially greater than the costs for those who do follow such a protocol – largely due to increased utilization of hospitals and emergency rooms, which are relatively more costly than physician and pharmaceutical services.

Several prospective studies have compared utilization and the corresponding costs of medical services by asthma patients for a period of time (usually a year) before an intervention program to those for the same period of time after the program. These studies focused on patients who had used acute care services (e.g., hospitalizations or emergency room visits) recently, and most evaluated patients who had a relatively high rate of utilization and a moderate or severe form of asthma. These studies therefore do not represent the experiences of the average patient. The data from these studies can be used to evaluate the costs of patient services before and after intervention for patients with a high use of services at the outset. By multiplying the average cost of utilization (e.g., for hospitalization) by the number of occurrences of utilization, before and after an intervention, and for each type of medical service considered, the average per-patient cost before the intervention can be compared to the average per-patient cost after the intervention. Each study thus affords an estimate of the extent to which complying with an asthma management protocol may reduce asthma-related medical costs — or, conversely, the extent to which failure to comply may increase these costs for some patients.

There are several factors, including the exact nature of the intervention, the utilization categories considered, and the severity of asthma in the study subjects, that would likely affect the ratio of before-intervention costs to after-intervention costs; these factors vary from study to study. Moreover, because these studies (some of which are pilot studies) were often based on relatively small samples and may not necessarily be representative of the population of asthmatic children as a whole, their results should not be

taken as definitive. They do, however, afford a rough idea of the magnitude and range of the extent to which the asthma-related costs of the "noncompliant" population of asthmatic children may exceed those of the "compliant" population of asthmatic children. The results of these studies are summarized in Table IV.2-2.

Table IV.2-2: Summary of Asthma Intervention Studies

	Higgins et al., 1998	Westley et al., 1997	Greineder et al., 1995	Gaioni et al., 1996
Utilization categories included in study:				
Hospitalization	x	x	x	x
ER visits	x	x	x	x
Office (clinic) visits	x	x		
Chest radiographs	x			
Inhaled anti-inflammatory drugs	x			
Beta-2 agonists	x			
Considered children separately?	yes	yes	yes	no
Number of subjects (children)	61	43	53	207
Were the estimated savings net of the costs of the intervention?	no	no	yes	yes
Ratio of before-intervention to after-intervention costs	7.62	3.60	3.84	2.01

These studies suggest that the asthma-related medical costs of children in the "noncompliant" population could be from twice to over seven times the costs of children in the "compliant" population. As noted above, however, several factors are likely to affect these ratios. First, the intervention programs differed from one study to another. Second, some studies took into account the cost of the intervention program itself, and considered the savings net of those costs, while other studies did not. Third, these studies generally selected asthmatics whose asthma was more severe than average, focusing primarily on patients with considerable hospitalizations and emergency room use prior to the study. Both their "before intervention" and "after intervention" acute care use rates are much higher than the national average. This frequency suggests that they would be categorized as patients with moderate or severe asthma. Fourth, these patients may have had much poorer compliance with management plans (or a lack of a plan) than other patients, leading to their very high acute care use rate at the outset of study participation.

The results of these studies shed light on the cost impacts that the variations in treatment may have. No single study fully illustrates national patterns of treatment, but the information in these and other studies is used later in this analysis as the basis for estimating medical costs for some patients. Additional detail is provided on the studies in Section IV.2.B.

IV.2.A.2. Concurrent Effects

Asthma usually occurs concurrently with allergies (as described above), although this is not always the case with adult-onset asthma. In the elderly it is often associated with other respiratory diseases such as chronic obstructive pulmonary disease (COPD). It has also been linked to other upper and lower respiratory tract diseases (e.g., sinusitis, rhinitis). It is not clear in most cases whether one disease triggered another.

As with most pharmaceuticals, those that are used to treat asthma have adverse side effects. Long-term use of corticosterioids have been associated with growth retardation in children and other serious health effects. There are also potential health risks listed for most other drugs used to control asthma. It is beyond the scope of this analysis to evaluate the health risks and potential direct medical costs of these secondary illnesses. These illnesses, however, are likely to occur in some patients and lead to an underestimate of medical costs when not considered.

Asthma may exacerbate cardiac and other problems. Asthma often leads to restricted activities in patients and a sedentary lifestyle that has been associated with numerous health problems. Asthma is a leading cause of activity restriction in children (NCHS web site, 1999). Perhaps most significantly, asthma during childhood has been associated with permanent structural changes in the lungs that are associated with adult respiratory diseases. This is one reason for the current focus in medical services on reducing episodes of asthma and the severity of the disease. Quantitative data were not obtained on the concurrent effects that result from the adverse physiological impacts of asthma. Due to the lack of information on these impacts, however, the cost estimates provided in this chapter, which focus solely on costs associated directly with asthma treatment, will underestimate total medical costs.

IV.2.A.3 Causality and Special Susceptibilities

Asthma usually begins in childhood and is often associated with atopy — the genetic susceptibility to produce IgE (an immune response) in response to exposure to common environmental allergens. Atopy occurs in 30 to 50 percent of the asthmatic population, and occurs in the absence of asthma in some individuals. It is the strongest predisposing factor for the

development of asthma. In young children who wheeze in response to viral infections, the presence of allergy in the child or their family is very strongly associated with asthma throughout childhood (NHLBI, 1997).

Other risk factors are neonatal lung disease, especially in infants with reduced lung volumes, and respiratory infections. Respiratory syncytial virus (RSV) has been particularly highlighted in association with asthma. Approximately half of all children with RSV bronchiolitis develop chronic asthma (Eggleston, 1994).

In adults asthma occurs both with and without IgE responsiveness. Without it, asthma is often associated with sinusitis, nasal polyps, and sensitivity to aspirin. Although the genesis may differ, the inflammatory process is similar to that seen in atopic asthma. Workplace exposures to some materials can also cause clinical signs of asthma, which may persist after the workplace exposure has ceased (NHLBI, 1997). Because asthma is often associated with atopy in response to exposure to common environmental allergens (NHLBI, 1997), these allergens are important asthma triggers. In adults asthma occurs both with and without IgE responsiveness and has been linked to numerous environmental agents.[8]

Numerous studies have identified air pollutants (e.g., particulate matter and ozone) as contributors to asthma (EPA, 1996). Hospitalizations for asthma have been shown to increase during air pollution episodes. Passive cigarette smoke (ETS) is also a strong instigator of asthma, with multiple studies showing associations between parental smoking and childhood asthma. EPA has provided a detailed summary of literature related to ETS through 1992 (EPA, 1992).

There has been an increase, as shown in the statistics presented earlier, in the incidence of asthma, asthma hospitalizations, and asthma deaths in recent decades. The specific causes of this increase are not known, although it has been hypothesized that air pollution and smoking in the home may be contributing factors.[9]

Appendix IV.2-A contains a list of many of the chemicals known or suspected of causing asthma that have been reported in the EPA Hazardous Substances Data Base (HSDB). High quality human dose-response studies are uncommon because non-pharmaceutical chemicals are rarely tested on

[8] The medical literature on asthma usually refers to external agents that can trigger asthma as "environmental factors," although they do not necessary mean "environmental" in the sense in which it is used in this Handbook. The environmental factors referred to in the literature include any aspects of the environment that are external to the body and include, but are not limited to, environmental pollutants.

[9] Maternal versus paternal smoking is a stronger risk factor for childhood asthma, and more women smoke now than in the first half of the century.

humans, which limits the information that can be obtained directly from human studies. Animal studies provide an additional source of information for links between a pollutant and disease. Potential causality of asthma as indicated by the HSDB toxicity excerpts was the only requirement for including a chemical in this table.

Regarding special susceptibility, it is difficult to determine whether an increase in the occurrence of a disease within a population group is due to genetic susceptibilities of the group, or a common characteristic that is unrelated to their genetic predispositions. That is the case with asthma, which affects a disproportionate number of socioeconomically disadvantaged minority children who often live in urban areas. It is likely that a combination of factors are at work in this case, including nutritional status, the presence of numerous pollutants in the environment, the greater likelihood that someone in the home smokes, less prenatal care, and other factors.

In addition to a greater likelihood of the occurrence of asthma, there is a greater likelihood that the same populations will be hospitalized for asthma, and that they will die of the disease (as shown in Table IV.2-1). Both of these endpoints indicate a much more severe case of asthma than what is routinely observed and can be treated through periodic office visits and self-medication with physician-prescribed treatments. At present there are clearly higher risks of the disease associated with the characteristics described above. These have environmental justice implications for benefits evaluations that focus on asthma.

Although socioeconomic and geographic factors may be the primary factors in the observed differences in asthma rates in the national population, genetic differences may also play an important role. This has recently been found to the case with some types of cardiovascular disease; African-Americans appear to have higher risks in some studies even when socioeconomic and other factors are carefully controlled. The rapid increase in asthma incidence and serious consequences has made careful evaluation of the risk factors for this disease difficult, and it has yet to be determined whether there are large differences within the U.S. population in the inherent (genetic) susceptibility to the disease (NHLBI, 1997).

IV.2.A.4 Treatment and Services

This chapter provides cost estimates that are based on a description of specific treatments and services provided to asthma patients. It is unlike chapters that use cost estimates obtained from journal articles or other sources. Because the cost estimates are generated for each specific service, very detailed treatment information is provided along with the costs of each

service. Consequently, treatment is more appropriately discussed in Section IV.2.B on cost. This section provides only a brief description of asthma treatment and services.

Treatment of asthma involves three phases: 1) initial diagnosis of the disease with efforts directed at immediate stabilization of the patient, 2) ongoing care to minimize episodes and maximize the quality of life of the patient, and 3) acute care for treatment of asthma episodes.

Depending on the severity of the asthma episode at initial diagnosis, a variety of treatment strategies are employed and may be provided on either an inpatient or outpatient basis. Follow-up care and long-term management of the disease involves multiple strategies. A major goal of asthma treatment is to enable patients to control their symptoms through the use of medications that they self-administer, and to control their exposure to situations that trigger their asthma episodes. This patient-centered focus requires determining the best long-term disease management approach and considerable training by medical personnel to achieve the objective of enabling the patient to live a life as free from asthma symptoms as possible (NHLBI, 1997).

Most asthma is managed through the use of drugs and avoidance of asthma triggers (e.g., allergens, irritants, behavior such as exercise in cold environments). When management is not adequate, asthma episodes occur that require more aggressive care, either provided at home or by a medical professional. These two scenarios, long-term management and acute episodic treatment, are reflected in the drug therapies offered to patients. Two major types of drugs are used to address these two circumstances: 1) long-term control agents: anti-inflammatory drugs that are self-administered;[10] and 2) acute control agents: bronchodilators that relieve acute symptoms (also self-administered, except in crisis). The drug therapies comprise the majority of costs in well-managed long-term asthma care. When long-term management is inadequate, as it often is for some groups of patients, episodes occur that require the use of acute control agents (and in some cases hospitalization, emergency room use, and mortality).

As the above paragraph indicates, this disease is largely a manageable disease for most patients. In practice, there are large differences in how well the disease is managed due to differences in treatment by medical care providers and the patient. As a result of this variation, the cost section of this chapter (Section IV.2.B) contains a discussion and cost evaluations based on differences in the use of medications and resulting medical services.

[10] Self-administered includes administration by a parent or non-medical care provider.

IV.2.A.5 Prognosis

Asthma is a chronic disease that is commonly observed in childhood, but it may be diagnosed or persistent at any age. Approximately 60 percent of asthmatic children undergo remission in young adult life, but 50 percent of those (30 percent of the original population) become symptomatic again as young adults. Among those who are asymptomatic as adults, some studies have shown that they retain airway hyperresponsiveness. Based on the above statistic, it is assumed in this analysis that 30 percent of asthmatic children will become permanently asymptomatic at age 18 and incur no additional medical costs for asthma treatment. Tests of airway hyperactivity show that the airways have not returned to normal among asymptomatic young adults who were previous asthma patients. As a general rule, children whose asthma is resolved are those with:

- less severe intermittent asthma;
- few positive skin tests to inhalant allergens;
- no persistent wheezing or rhonchi; or
- no heavy exposure to pollution, allergens, or cigarette smoke (Eggleston, 1994).

The assumption that 30 percent of children will undergo remission is based on observations made in the past. It is not known if the remission rate at this time is the same as it was when the 30 percent statistic was observed. It is also not known which percentage of asthmatics in any severity category (discussed below), will undergo remission. In this analysis it was assumed that the severity mix among asthmatics who became asymptomatic was the same as the mix in the original asthma population. This assumption introduces uncertainty to this cost analysis.

Although many children see a gradual lessening of symptoms as they progress toward adulthood, this is not universally the case. In some cases, the disease becomes more severe and in rare cases is fatal. As discussed under Concurrent Effects above, damage that is done to lung tissue and structure during asthma episodes may lead to adverse long-term or permanent changes in the lung. Current treatment strategies are designed to minimize the inflammatory processes that occur during an asthma episode, in part to avoid long-term damage to the respiratory system (NHLBI, 1997).

The long-term disease course and effects of asthma differ among individuals. In some patients fibrosis of the subbasement membranes in the respiratory system may occur, and this may contribute to persistent abnormalities in lung function in these individuals (NHLBI, 1997). Due to concerns regarding the irreversible damage that can occur, effort is being

focused on early diagnosis, limiting the severity of the disease, and drug therapy that minimizes the inflammation causing structural changes in the respiratory system (NHLBI, 1997).

When considering the prognosis for asthma patients, it is necessary to take into account both the recurrence of asthma episodes and the effects that treatment of asthma may have on overall health. Inflammation is an early and persistent component of asthma and therapy to suppress it is long term. Greater asthma control achieved with high doses of inhaled corticosteroids causes less airway inflammation. The drug therapies used to control asthma episodes are not without side effects, as discussed previously. There are a variety of products on the market and each has specific advantages and disadvantages. There is some evidence that some of the most effective asthma treatments also lead to growth retardation in children. Consequently, the prognosis for this disease must take into account both the long-term nature of asthma in many individuals and potential damage to the patient that results from control of asthma symptoms. Quantitative data on long-term prognosis is not available for newly-diagnosed patients because many new drugs have been introduced recently.

Urban residence and poverty are major risk factors for asthma morbidity and mortality. There are areas of increased mortality in cities, especially among people in lower socioeconomic groups (Eggleston, 1994).

Mortality due to asthma is a rare event. The mortality rate for asthmatics is 0.0004 (see Table IV.2-1 above).[11] Some population subgroups have much higher rates than average (for example, teenagers in lower socioeconomic groups). Increased mortality among young and otherwise healthy patients has been associated with an inability to understand or comply with the sometimes demanding drug and activity regimens required to control asthma episodes. They may also be less likely or able to obtain timely health care for acute episodes.

Link to Table IV.2-1

As discussed in the section IV.2.A.4 above, there are differences in how individual patients manage their disease. These differences can lead to major differences in the prognosis among patients. Self- or parental management of the disease is much more important for asthma than for most diseases discussed in the Handbook. This distinction places a large burden on the medical community regarding outreach, education, patient tracking, and follow-up care. Ultimately, the prognosis for asthma patients depends largely on their ability and interest in managing their disease

[11] The value of a statistical life (VSL) can be computed for those patients who die of the disease when asthma avoidance is being considered in a benefits analysis.

through complying with treatment plans. Asthma deaths have occurred among patients with mild, moderate, and severe asthma, and so are not strictly related to the severity of the disease. Both hospitalizations and mortality are strongly related to the degree of control of inflammation and a timely response to acute asthma episodes. Patient (or caregiver) education, access to medical care, and appropriate use of drug therapies are very strong determinants in the overall prognosis for asthma patients.

Link to Section IV.2.A.4

IV.2.B. Costs of Treatment and Services

This section contains a description of the methodology used to estimate cost, followed by a description of the services provided for the three main components of care: diagnosis, long-term management and acute care management, and a presentation of the costs of these services. Costs are presented on an annual and lifetime basis for both the average and high services use patient.

IV.2.B.1. Methodology Summary

Estimates of the direct costs of asthma are constructed using national data on asthma medical services, utilization, reimbursement by Medicare, and national recommendations and private sector costs regarding drug therapy. The probabilities of patients utilizing various services are multiplied by the cost per service. The methodology by which estimates of the lifetime incremental costs are developed proceeds in four steps:

1) Develop treatment descriptions and probabilities,
2) Estimate the cost of each treatment component,
3) Estimate the annual costs of treatment, and
4) Sum costs over the lifetime of an average patient and apply discount rates.

After initial diagnosis, asthma management can be considered as two separate activities: long-term management and management of acute episodes. Long-term management includes the establishment of an appropriate treatment program, education for the patient and for family members to allow them to manage the disease, and office visits to evaluate the patient's ongoing health and use of medications. It also includes the drug therapy that is used to manage the disease. Acute episode management focuses on reducing symptoms of an acute asthma attack and preventing further damage to the patient's health. This section is organized according to the treatment components listed above, with diagnosis described first, followed by long-term management and then acute episode management.

IV.2.B.1.1 Treatments and Services Evaluated

The first step in estimating the cost of the disease is to model the typical course of the disease and the corresponding treatment. Three main sources were used to construct disease course and treatment profiles for asthma in this chapter: NHLBI Guidelines (NHLBI, 1997 — primary source), data from the literature, and, to a limited degree, data from a physician panel convened in 1991.[12]

Asthma treatments and costs have three main components:

1) diagnosis,
2) long-term management, and
3) acute episode management.

Diagnosis is required for all patients, and the types of diagnostic tests and evaluations conducted are assumed to be the same for all patients (although differences may exist among care providers). Long-term management consists of office or outpatient visits and self-administered drug therapy. Acute care results from immediate health emergencies that require emergency room use and/or hospitalization. These components of health care are first described (in Sections IV.B.2, 3, and 4) and then the costs of the services are presented and discussed (in Section IV.B.5).

IV.2.B.1.2 Evaluation of Differences in Asthma Management [13]

IV.2.B.1.2.1 Overview of Issues

As discussed in Section IV.2.A.1.11 above, under optimal circumstances all patients would have a long-term asthma management plan that managed the symptoms of asthma sufficiently well that they did not have asthma episodes requiring medical intervention. In practice, many patients either do not receive drug plans, or do not follow drug plans that manage asthma at this level of control. The lack of adequate medication often leads to higher costs for office visits and acute care (emergency room use and hospitalization).

Link to Section IV.2.A.1.11

[12] A panel of three physicians (two pulmonologists and an internist) was convened in 1991 to determine a standard treatment protocol and the percentage of patients receiving various types of treatments. The purpose of the panel was to supply information that was used to develop the first asthma COI chapter in 1991. These physicians, all from New England, did not represent a cross-section of primary care physicians who treat most asthma cases. Aware of these limitations, they reviewed Medicare treatment records and other materials and attempted to provided useful information on overall treatment patterns. The information they provided has been largely superseded by NHLBI guidelines and other information.

[13] All referrals to asthma management acknowledge that this process involves both the medical community and the patient, due to the importance of self-medication and other activities in asthma treatment.

As discussed in Section IV.2.A.1.11 above, some patients use services at a much higher rate than the average patient, suggesting that substantial differences exist in the utilization of medical services and the resulting costs among asthma patients. In addition to obtaining a cost estimate for the "average" patient, it would be useful to obtain cost estimate for patients with two different patient profiles: one in compliance with treatment plans (such as those specified by NHLBI guidelines), and one that does not have well-managed asthma and has health problems related to the management plan. There are limited data on the variations in treatment that preclude providing highly reliable national estimates for these two patient groups, but there are some studies of high-use patients (as discussed in Section IV.2.A.1.11). These studies were used to describe a hypothetical patient who is not following an optimal treatment plan and incurs the associated higher medical costs.

IV.2.B.1.2.2 Patient Types Evaluated in this Cost Analysis

Descriptions of treatments and costs are provided for two types of patients:

1) the average patient: a profile was developed using national statistics on office and outpatient visits, emergency room use, and hospitalization, as described in Section IV.2.A, Table IV.2-1. No data are available on drug therapy use, so NHLBI guidelines are assumed to be relevant. Issues related to drug therapy are discussed below.

Link to Table IV.2-1

2) the high-use patient: a profile was developed using studies of patients who have difficulty managing their asthma with a larger number of acute episodes than average. The estimate of their hospital and emergency room use is based on studies that evaluated the experiences of patients before they had training on how to follow their management plans. These patients tend to have moderate or severe asthma. Their costs provide a type of reasonable upper bound on costs.

Ideally, data would be available on patients with mild asthma who are in compliance with treatment plans and have a resulting low utilization of acute care services. These data, which could provide a lower-bound cost estimate, are not available. The studies that evaluated "before" and "after" intervention included mainly patients who had serious acute care problems and were not likely to include mild asthma cases.[14] Consequently, although

[14] Mild asthma is estimated to comprise 70 percent of all asthma cases, as discussed below.

data are available on the impact of intervention on high-use patients, there are no data on a cross section of asthma patients.

As discussed above, asthma treatments and costs have three main components (diagnosis, long-term management, and acute episode management). Diagnostic methods and costs are likely to be similar regardless of the subsequent decisions of patients or their physicians. Long-term management and acute episode services will vary, depending on the factors discussed above. Although the number of hospitalizations and emergency room visits are assumed to vary for the two patient types, the level of services provided during hospitalization and emergency room visits are *not* assumed to differ. (There is no basis on which to assume that the services would differ.)

IV.2.B.1.2.3 Quantitative Data on Treatment and Services for Two Patient Types

The Average Patient. National statistics listed in Section IV.2.A Table IV.2-1 on treatment and services were used (office/outpatient visits, emergency room use, and hospitalization).

Link to Table IV.2-1

The High-use Patient. Table IV.2-3 lists the frequency of use of various services before and after the intervention of an asthma management program. The "before" statistics have been used to develop a hypothetical "high-use" patient profile, to provide an indication of the high costs that can be associated with asthma in the absence of adequate disease management. (The data in this table expand on information provided in Table IV.2-2.) The "after" data are used in the sensitivity analysis presented in Section IV.2.C.

Although studies indicate that inadequate disease management is a relatively common problem, data were not located that adequately describe the percentage of asthma patients with this problem or its extent. Consequently, this analysis does not assign the "high-use" costs to a specific proportion of asthma patients. It is likely that these patients' use of acute care services comprises a substantial portion of the overall national acute care services use reflected in the "average" patient costs referred to above.

Table IV.2-3: Acute Care Utilization Rates for "High-use" Asthmatics Before and After Participation in an Asthma Management Program									
Study	Utilization Rate Per "High-use" Asthmatic per Year								
	Hospitalization			Emergency Room Visits			Office (Clinic) Visits		
	Before Intervention	After Intervention	Ratio	Before Intervention	After Intervention	Ratio	Before Intervention	After Intervention	Ratio
Higgins et al., 1998	0.149	0.070	2.13	0.498	0.316	1.58	2.587	3.724	0.70
Westley et al., 1997	0.530	0.190	2.79	3.670	1.350	2.72	4.395	2.442	1.80
Greineder et al., 1995	0.660	0.094	7.00	1.358	0.283	4.80	—	—	
Gaioni et al., 1996	0.758	0.169	4.49	1.126	0.304	3.70	—	—	
Mayo et al., 1990	1.560	0.480	3.25	—	—	—	—	—	
Average Across Studies:	0.732	0.201	3.93	1.663	0.563	3.20	3.491	3.083	1.25
Average Asthmatic (for Comparison)	0.034			0.117			0.707		

IV.2.B.1.3 Duration of Treatment and Services

Although patients can be diagnosed with asthma at any point in their lives, most people are diagnosed as children. As noted earlier, the average age of diagnosis is four years (Eggleston, 1994) and that is the age that is used as the average onset of the disease for this analysis.. As noted above, asthma patients are assumed to live a normal lifespan due to the minimal mortality due to asthma. An average life expectancy of 75 years was assumed for purposes of estimating care duration and cost.[15] This lifespan is recommended in EPA's Exposure Factors Handbook for general use (EPA, 1997), which yields an overall lifespan with asthma of 72 years (from age 4 through age 75). There is an assumption that 30 percent of patients with mild asthma become asymptomatic and no longer require treatment at age 18. (See discussion in Section IV.2.A.5.).

Link to Section IV.2.A.5

Life expectancy increases as individuals survive through each year of their life, so that by the average age of diagnosis (four years) life expectancy is longer than 75 years for the average person in the United States. This figure is balanced by the likelihood that people with chronic illnesses, such as asthma, have a decreased life expectancy due to asthma and related illnesses or the side-effects of treatment. The average duration of treatment is uncertain for asthmatics, and the actual duration and associated costs may be greater or lesser than the value estimated in this analysis.

IV.2.B.2 Diagnosis

IV.2.B.2.1 Medical Evaluation During Diagnosis

The diagnosis of asthma usually occurs in response to the observation of symptoms that prompt a visit to a physician's office or emergency room (ER). It may also occur when a routine physical is scheduled, especially in the case of children. Treatment in an ER does not imply a severe medical condition; rather, it indicates an acute problem and may be the medical location of choice for some patients who do not have a regular physician, or when an asthma episode occurs outside of usual office hours. NHLBI does not distinguish among diagnoses in different settings when describing the diagnostic protocol (NHLBI, 1997).

Medical evaluation needed to diagnose asthma is not complex in most cases. Asthma is indicated by an appropriate array of symptoms, an acute

[15] There may be mortality due to therapy or other aspects of asthma that are not well-described at this time. In the absence of information to the contrary, it was reasonable to assume a normal lifespan for asthmatics.

reaction to asthma-related stimuli, and quick relief by appropriate therapy. Other supporting evidence may include family history, an elevated IgE level, and eosinophilia (Eggleston, 1994).

When considering a diagnosis of asthma, NHLBI recommends the following:

- careful history-taking (specific questions can be viewed at the NHLBI web site),
- physical examination, and
- spirometry to evaluate air flow.

Beyond the above activities, NHLBI discusses some specific procedures that may be dictated by the patient's characteristics and history, but that are not required for most patients. These may include:

- additional pulmonary function tests (lung volume, inspiratory and expiratory flow loops, diffusion capacity test (primarily in older patients));
- diurnal variation in PEF over one to two weeks;
- bronchoprovocation with methacholine, histamine, or exercise;
- chest X-ray;
- allergy testing;
- screening for nasal polyps and sinus disease;
- evaluation of gastrointestinal reflux;
- evaluation of biomarkers of inflammation (in development); and
- other tests to rule various diseases suggested by patient symptoms.

Many of the above additional evaluations have specific and narrow indicators for their use and are not needed for most patients. It is not possible to determine the percentage of patients that are evaluated for each of the above. Some of the evaluations would be done during a second diagnostic visit to a specialist (e.g., allergy testing) or may be characteristics observed by the patient and reported back to the physician (e.g., diurnal variation in PEF over one to two weeks). Second diagnostic visits are considered below. The other evaluations listed above are beyond the scope of this analysis, but their inclusion would increase costs. Thus, their exclusion leads to an underestimate of costs.

Diagnosis of asthma is difficult in young children. They are often diagnosed as having bronchitis, bronchiolitis, or pneumonia. In infants there are two patterns of wheezing (a critical observation in asthma), allergic and nonallergic. As children develop, the nonallergic infants no longer wheeze during colds and other minor illnesses because their airways

enlarge. Allergic children continue to have episodes when their airways constrict and may be diagnosed with asthma (AAFA, 1999).

Diagnoses of asthma are not frequently made in children under the age of one year. When wheezing and related symptoms occur prior to that age, they are generally diagnosed as bronchiolitis or other diseases that cause wheezing, with the understanding that they may later be diagnosed as asthma. The symptoms that occur prior to one year may be "asthma" in the pragmatic, if not clinically defined, sense of the term. When asthma is diagnosed in much older children, it may be because their symptom onset occurs later or because there is a delay in diagnosis beyond the onset of symptoms, which can lead to more severe forms of asthma when diagnosis occurs. Numerous studies have suggested that an underdiagnosis of asthma is a public health problem.

IV.2.B.2.2 Services Provided During the Diagnostic Visit

Based on NHLBI guidelines and the 1991 panel recommendations, components of the diagnostic visit (that are costed individually for Medicare reimbursement) are listed in Table IV.2-4. As discussed previously, services will vary depending on patient characteristics, the physician's practice methods, and other factors.[16] X-rays were included in this list because they appear as a possible procedure in NHLBI guidelines and were listed by the 1991 physician panel as a diagnostic procedure.

Table IV.2-4: Diagnostic Procedures

Chest X-Ray, Two Views
Blood Gases: pH, pO2, pCO2
Automated Hemogram
Breathing Capacity Test
Office Visit, Level 5, New Patient
Drawing Blood for Specimen

Diagnosis may occur at a physician's office, in a hospital outpatient clinic, or in an emergency room. It is assumed in this analysis that an outpatient clinic would provide essentially the same services for the same cost as a physician's office. When diagnosis occurs in an emergency room, it may be that the patient is experiencing symptoms that require immediate attention or that medical care is unavailable via other means (e.g., they do not have a personal physician. Due to the potentially more serious nature of their symptoms, there *may* be additional services provided. These services may include: a complete blood count (CBC), theophylline administered

[16] The NHLBI does not recommend different evaluations during diagnosis based on severity (severity category is determined during diagnosis, not at the onset of the process).

intravenously, nebulizer therapy, or other services that are medically required (as described by the 1991 physician panel). These added services will lead to increased costs not considered in this analysis. (A description of services and the costs for an emergency room visit are described below.)

Emergency room staff often do not have information available on the medical history of a patient, so may treat each patient entering the emergency room with asthma as a new diagnosis (Physician panel, 1991). That was the assumption made when developing the description of services and costs for the emergency room services discussed below. This description and the associated costs may be relevant for both initial diagnosis in an emergency room and visits to the emergency room that occur after diagnosis. Whether this is the case will depend on the specific hospital's practices, and whether the patient was referred to the emergency room by a physician who provided the patient's medical history to the hospital.

IV.2.B.2.3 Asthma Severity Level

When diagnosed with asthma, the severity of the patient's disease is evaluated and a severity category is assigned. These categories are subsequently used to develop an asthma management plan for the patient. The National Heart, Lung, and Blood Institute (1997) has developed a classification scheme for asthma by severity of disease. Patients are diagnosed at their initial visit (or a subsequent visit to a specialist) with either mild intermittent, mild persistent, moderate persistent, or severe persistent asthma based on this classification scheme. Treatment plans and costs vary depending on the severity of the asthma. The classification scheme, shown in Table IV.2-5, shows symptoms and lung function measures that are used to categorize asthma (NHLBI, 1997).

Recent information was not located in the literature regarding the distribution of patients into the various categories listed above. Estimates are available from the 1991 physician panel: approximately 70 percent of asthmatics have mild asthma, 25 percent have moderate asthma, and 5 percent have severe asthma. In their 1997 publication, NHLBI separated mild asthma into two components, intermittent and persistent (NHLBI, 1997). For purposes of this analysis, it is assumed that half of those with mild asthma are in each diagnostic category.

It is also assumed that the 1991 panel's estimate of the percentage of patients in each category is currently accurate. Due to increases in the occurrence and acute services use by asthmatics in recent years, it is possible that more patients are now in the moderate and severe asthma categories than in the past. Uncertainty exists regarding this distribution because data on the current severity distribution are not available. This uncertainty does not impact service utilization, which is not based on severity in this analysis (it is based on national statistics and the results of

studies of service utilization). Severity categories are used, however, to estimate drug therapy use and cost. Consequently, if the severity distribution among asthma patients is currently more severe than it was in 1991, the costs of drug therapy will be underestimated. As better information becomes available and/or practices change, the percentages can be modified to reflect current knowledge.

In this analysis, patients were assumed to retain the severity level that they were originally diagnosed up to age 18. Beyond that age it was assumed that 30 percent become symptom-free (Eggleston, 1994; see discussion in Section IV.2.A.5). The remaining 70 percent continue to require treatment at the severity level at which they were originally diagnosed. As with the severity distribution, the percentage of patients becoming symptom-free may differ from estimates made in the past.

Link to Section IV.2.A.5

Table IV.2-5: Classification of Asthma Severity			
Clinical Features Before Treatment*			
	Symptoms**	**Nighttime Symptoms**	**Lung Function**
STEP 4 Severe Persistent	• Continual symptoms • Limited physical activity • Frequent exacerbations	Frequent	• FEV_1 or PEF $\leq$ 60% predicted • PEF variability > 30%
STEP 3 Moderate Persistent	• Daily symptoms • Daily use of inhaled short-acting $beta_2$-agonist • Exacerbations affect activity • Exacerbations $\geq$ 2 times a week; may last days	> 1 time a week	• FEV_1 or PEF > 60%-<80% predicted • PEF variability > 30%
STEP 2 Mild Persistent	• Symptoms > 2 times a week but < 1 time a day • Exacerbations may affect activity	> 2 times a month	• FEV_1 or PEF $\geq$ 80% predicted • PEF variability 20-30%
STEP 1 Mild Intermittent	• Symptoms $\leq$ 2 times a week • Asymptomatic and normal PEF between exacerbations • Exacerbations brief (from a few hours to a few days); intensity may vary	$\leq$ 2 times a month	• FEV_1 or PEF $\geq$ 80% predicted • PEF variability < 20%

* The presence of one of the features of severity is sufficient to place a patient in that category. An individual should be assigned to the most severe grade in which any feature occurs. The characteristics noted in this figure are general and may overlap because asthma is highly variable. Furthermore, an individual's classification may change over time.

** Patients at any level of severity can have mild, moderate, or severe exacerbations. Some patients with intermittent asthma experience severe and life-threatening exacerbations separated by long periods of normal lung function and no symptoms.

IV.2.B.2.4 Drug Therapy During Diagnosis

A patient is initially diagnosed with asthma may receive two types of drug therapies that are consistent with the two aspects of managing asthma:

1) *Long-term care.* The patient will receive a management plan that includes long-term drug therapy for control of their disease. If this management plan adequately controls symptoms, the patient will be maintained on that plan, with subsequent review to determine if dosages can be "stepped down" and still maintain control over the disease.

2) *Episodic care*. A patient diagnosed in response to an asthma episode will receive drugs during the visit to address current symptoms. These will be short-acting drugs that are used in response to asthma episodes rather than for long-term disease management.

In both cases, the drug regimens do not differ from those that would be used under similar circumstances after initial diagnosis. Consequently, they are discussed below under the two relevant headings: Long-term Management and Management of Acute Episodes. The specific therapeutic drugs that are recommended for use when asthma is initially diagnosed vary, depending on the disease symptoms, patient characteristics, and the physician's prescribing habits. There are two main groups of drugs used to treat asthma, one for long-term management of the disease and one for quick relief of symptoms.

In the cost section below, drug costs are assumed to begin when the diagnosis is made at age four. The drugs prescribed or given in the physician's office at diagnosis will be the same as those used during the subsequent long-term management and quick-relief management. Consequently, the specific drugs are discussed below under those two headings. Separate drug costs are not assigned to the diagnostic process because they are the same as those itemized under the Drug Therapies section below.

IV.2.B.2.5 Referral to Specialists During Diagnosis

Most people with asthma are diagnosed by and receive care from a primary care physician. NHLBI does not suggest that diagnostic procedures vary depending on the severity category in which the patient may be ultimately diagnosed. Consequently, it is assumed that all patients will undergo similar diagnostic procedures, although NHLBI recommends referral to specialists in asthma treatment (e.g., a pulmonologist) under specific circumstances. The conditions leading to referal are related to ongoing care and meeting treatment goals unrelated to the initial diagnosis; consequently, they are not discussed in this section. Some criteria are relevant at diagnosis, and one (criterion 5) is related to the severity category of the patient. The criteria are:

1) signs and symptoms are atypical or there are problems in differential diagnosis;

2) other conditions complicate asthma or its diagnosis;

3) additional diagnostic testing is indicated (e.g., allergy testing, complete pulmonary function studies, rhinoscopy, provocative challenge, bronchoscopy);

4) patient is being considered for immunotherapy;

5) patient has severe persistent asthma (Step 4, as shown in Table IV.2-5), or is under age three and has moderate or severe persistent asthma (Step 3 or 4) and in some cases mild persistent asthma (Step 2); and

6) patient has significant psychiatric, psychosocial, or family problems that interfere with asthma therapy. (NHLBI, 1997, refer to this source for additional detail)

Link to Table IV.2-5

Referral to a specialist occurs when a patient's asthma or some other health characteristic is complex and requires more sophisticated investigation and/or treatment. This analysis does not attempt to speculate on what specialized treatment would be provided because the reasons for referral and the resulting treatments vary widely. The analysis assumes that the cost of treatment by a specialist would be the same as the cost of the initial office visit for diagnosis. This is a conservative assumption, because it is likely that the treatment would be at least as complex (and costly) as the initial office visit for diagnosis.

It is not known what percentage of patients may experience any of the above, but an estimate can be made for criterion 5. As discussed previously, the 1991 physician panel provided an estimate of the percentage of individuals who fall into each severity category. Using this information, the percentage of patients who would be referred to a specialist based on criterion 5 can be estimated. It was estimated in 1991 that 70 percent of asthmatics have mild asthma (35 percent persistent, 35 percent intermittent), 25 percent moderate, and 5 percent severe asthma. Using this information with criterion 5, an estimate of the number of patients who will see a specialist following their initial visit with a primary care physician was made as follows:

For severe asthma: the 5 percent of patients with severe asthma will all be assumed to consult a specialist.

For moderate asthma: the criterion is age-related. There is not a distribution of ages of diagnosis available; however, if four years is the median age of diagnosis (50 percent above and 50 percent below), then it will be assumed that half of all patients were diagnosed at age three or younger. Thus, one half of the 25 percent of patients with moderate asthma, or 12.5 percent of all asthma patients, will be assumed to consult with a specialist.

For mild asthma: there is not quantitative guidance provided for those with mild asthma. Based on the numerous criteria for referral to specialists, the substantial number of very young children who have asthma (and are more difficult to evaluate and treat) and the statement that some cases of mild persistent asthma will require referral to a specialist, it was assumed that one half of those with mild asthma, or 35 percent of all asthma patients, will consult a specialist. ***Aggregating the three categories above, the total percentage of patients who are assume to consult with a specialist***

following initial consultation with a primary care physician is 52.5 percent.

It was assumed that patients meeting this criterion would meet with a specialist after the first diagnostic visit, for additional diagnosis and planning evaluations. As noted above, the specific additional evaluations that are performed in this visit will vary depending on the reason for referral and patient characteristics. Consequently, the specific activities cannot be estimated. It is reasonable to assume that they will be at least as complex (and as costly) as those provided by the primary care physician in the first diagnostic visit.

IV.2.B.2.6 Level of Visit and Number of Visits for Diagnosis

To estimate the costs of office visits, it is necessary to specify the level of visit (1 to 5), which is determined by the length of the visit. Visits for asthma include a number of activities related to the initial diagnosis, including the determination of the appropriate treatment plan through tests, history taking, physical exam and evaluation, explanation of the disease and management plan to the patient (or parent), and patient education regarding drugs and equipment. A second visit follows shortly after diagnosis to determine if the treatment plan is managing the disease adequately; additional patient education may also be provided.

NHLBI has emphasized the importance of education and the management of asthma by the patient and physician as key elements of care. Emphasis is also placed on quality of life issues, which is closely tied to adequate disease management (NHLBI, 1997). These foci require considerable time be spent by medical staff on training and education of patients. This is particularly true due to the daily need for self-medication for many asthmatics and the use of inhalers and peak flow meters. The result of all this is a requirement that more time be spent during office visits than is spent for many other chronic diseases.[17] Due to the time requirements, this analysis assumes that a single maximum duration (level 5) office visit would be used for the initial diagnostic consultation.

[17] Consultation with one pediatrician who treats many asthma cases suggests that considerable time is required for adequate patient education. He routinely spent one hour or more explaining the disease and training the patient, which was followed by later consultations with nurse practitioners. It was felt that this time investment was necessary to ensure that patients understood their treatment plans, how to avoid asthma triggers, how to use inhalers and peak flow meters, and other aspects of their disease.

NHLBI guidelines indicate that the first diagnostic visit is followed shortly by another visit to determine if the management plan is adequate for the patient, and to make any necessary adjustments. Additional patient education may also be provided.[18] This analysis assumes that a second visit will follow the first within a short time frame as part of the diagnostic process. Within the set of those patients who require adjustment of their treatment plans at this visit, there may be a subset that require another visit to determine if the modified plan was optimal. The percentage of patients requiring this third visit is not known. Consequently, this visit and any subsequent planning visits related to initial diagnosis are not included. The assumption that only two visits are required will cause an underestimate of medical cost in this analysis.

IV.2.B.3 Long-term Management

Long-term management of asthma involves ongoing use of medications and asthma trigger avoidance by patients. It also requires periodic assessments and monitoring by medical care providers. For purposes of cost evaluation the focus of this discussion is on:

1) the office visits or hospital outpatient visits that occur, and
2) the drug therapy regimen that is prescribed for the patient.

No skilled nursing or therapeutic services are typically provided to asthmatics in their homes, so costs for such services are not included in this analysis. It is assumed that severe asthmatics will use a nebulizer with compressor in the home on an ongoing basis. This cost (which is minimal) is listed with drug therapy, since it is self-administered and is more closely related to drug therapy than to medical services.

As discussed above, the frequency and complexity of long-term care depends substantially on the patient receiving an adequate treatment plan, understanding it, and complying with it (particularly self-administered drug regimens). Consequently, an estimate of the patient's use of treatment and services and their cost is provided for an average patient, as well as for high-use patients. When a patient is managing their exposures to asthma triggers adequately and self-administers drugs that prevent asthmatic crises, the course of their therapy and resulting costs for many patients may be fairly predictable. When management is inadequate, there will be asthma episodes requiring different self-administered drugs, more office and emergency room visits, and potential hospitalization (discussed in the following section). In either case, there will be office visits and self-medication.

[18] It has been observed that many patients need to be checked for use of their asthma therapy equipment. At one children's asthma camp, it was observed that as few as ten percent of patients appeared to be using their inhalers correctly (Aligne, 1999).

IV.2.B.3.1 Long-term Management for the Average Patient

IV.2.B.3.1.1 Office Visits

The number of office visits an average asthma patient makes per year was estimated using CDC data reported in Section IV.2.A to be 0.707 (see Table IV.2-1). The services provided during office visits are shown in Table IV.2-4 (based on information from the 1991 physician panel and a review of information in NHLBI guidelines). The categories of services shown in the table below are those specified for Medicare reimbursement and do not provide detailed descriptions of services. For example, the activities of the physician (e.g., history taking, discussion of symptoms, education of the patient, etc.) are not specifically listed in the table, but are assumed to fall under the category of "office visit."

Link to Table IV.2-1
Link to Table IV.2-4

Table IV.2-6: Asthma: Description of Follow-Up Care by Severity Level

Chest X-Ray, Two Views
Assay for Theophylline
Breathing Capacity Test
Office Visit, Level 5, Established Patient
Drawing Blood for Specimen

For some patients who have difficulty managing their asthma through treatment plans, NHLBI recommends additional evaluations and activities that are similar to those listed under Section IV.A.2.5, above(e.g., allergy testing, immunotherapy). These additional steps will result in additional costs that are not considered in this analysis, due to a lack of detailed information on their use, and will cause an underestimate of total costs.

Link to Section IV.A.2.5

IV.2.B.3.1.2 Drug Therapies

As noted above, no data are available on the actual practices of asthmatics regarding drug use. Consequently, NHLBI guidelines were used as an estimate of drug use and costs. Aside from drugs administered during acute episodes in a medical care setting, most asthma drugs are self-administered, following directions provided by a physician. NHLBI recommends that most patients be treated with self-administered long-term asthma medications to reduce inflammation. All patients but those with

mild intermittent asthma (approximately 35 percent of patients) are encouraged to have daily anti-inflammatory medication. NHLBI also recommends the self-administration of "quick-relief" medications to deal with asthma episodes. The type of drugs, their quantity, and their frequency of use depends on the severity of the asthma and specific characteristics of the patient. Pharmaceutical usage is discussed by level of asthma severity in this analysis because it is not possible to determine the distribution of specific patient characteristics. Both the costs of various drug alternatives, and drug costs for different management plans, will vary.

Although NHLBI drug therapy guidelines were used in this analysis to estimate drug costs, the distribution of drugs between long-term management and quick relief medications may differ among patients. Among patients whose asthma is not well managed, there may be a greater use of quick-relief medications for acute episodes and less use of drugs used for long-term management among many patients. Study data (discussed below) suggest that many patients do not manage their disease in a manner that provides long-term low-level care, but rather use medication when they experience symptoms. As described in Section IV.2.A, a lack of disease management causes asthma attacks. Consequently, those who don't use preventive long-term care drugs are likely to need a greater amount of short-term relief medications. Given this trade-off, the drug costs are not expected to differ substantially among patients in the average versus high-use categories considered in this analysis (although hospitalization and emergency room use are, as discussed below).

The NHLBI recommends the therapies shown in Table IV.2-5 for initial management planning for children age five and under, and those shown in Table IV.2-6 for patients older than five years of age.

Table IV.2-7: Stepwise Approach for Managing Asthma in Infants and Children under 6 Years of Age

Adapted from NHLBI, 1997. Sections dealing with education and cautions are not included.

	Long-term Control	**Quick Relief***
STEP 4 Severe Persistent	Daily medications: • Daily anti-inflammatory medicine — High-dose inhaled corticosteroid with spacer/holding chamber and face mask — If needed, add systemic corticosteroids 2 mg/kg/day and reduce to lowest daily or alternate-day dose that stabilizes symptoms *beclomethasone dipropionate*	• Bronchodilator as needed for symptoms (see step 1) up to 3 times a day *albuterol* .
STEP 3 Moderate Persistent	Daily medication: • Daily anti-inflammatory medication. Either: — Medium-dose inhaled corticosteroid with pacer/holding chamber and face mask OR, once control is established: — Medium-dose inhaled corticosteroid and medocromil OR — Medium-dose inhaled corticosteroid and long acting bronchodilator (theophylline) *beclomethasone dipropionate*	• Bronchodilator as needed for symptoms (see step 1) up to 3 times a day *albuterol*
STEP 2 Mild Persistent	Daily medication: Daily anti-inflammatory medication. Either: — Cromolyn (nebulizer is preferred; or MDI) or nedocromil (MDI only) — Infants and young children usually begin with a trial of cromolyn or nedocromil OR — Low-dose inhaled corticosteroid with spacer/holding chamber and face mask *cromolyn*	• Bronchodilator as needed for symptoms *albuterol.*
STEP 1 Mild Intermittent	• No daily medication needed.	• Bronchodilator as needed for symptoms $\leq$ 2x / week Inhaled short-acting beta2-agonist by nebulizer or face mask and spacer/holding chamber *albuterol*
Step down Review treatment every 1 to 6 months; a gradual stepwise reduction in treatment may be possible.		**Step up** If control is not maintained, consider step up. First, review patient medication technique, adherence, and environmental control (avoidance of allergens or other factors that contribute to asthma severity).

Table IV.2-7: Stepwise Approach for Managing Asthma in Infants and Children under 6 Years of Age

Adapted from NHLBI, 1997. Sections dealing with education and cautions are not included.

	Long-term Control	Quick Relief*

NOTE:

- The stepwise approach presents general guidelines to assist clinical decision making; it is not intended to be a specific prescription. Asthma is highly variable; clinicians should tailor specific medication plans to the needs and circumstances of individual patients.
- Gain control as quickly as possible; then decrease treatment to the least medication necessary to maintain control. Gaining control may be accomplished by either starting treatment at the step most appropriate to the initial severity of the condition or starting at a higher level of therapy (e.g., a course of systemic corticosteroids or higher dose of inhaled corticosteroids).
- A rescue course of systemic corticosteroids may be needed at any time and at any step.
- Some patients with intermittent asthma experience severe and life-threatening exacerbations separated by long periods of normal lung function and no symptoms. This may be especially common with exacerbations provoked by respiratory infections. A short course of systemic corticosteroids is recommended.
- At each step, patients should control their environment to avoid or control factors that make their asthma worse (e.g., allergens, irritants); this requires specific diagnosis and education.
- Referral to an asthma specialist for consultation or co-management is recommended if there are difficulties achieving or maintaining control of asthma or if the patient requires step 4 care. Referral may be considered if the patient requires step 3 care.

* In all quick relief cases, the “intensity of treatment depends on severity of exacerbation” (NHLBI, 1997).

Table IV.2-8: Stepwise Approach for Managing Asthma in Adults and Children Older than 5 Years of Age: Treatment
Adapted from NHLBI, 1997. Sections dealing with cautions are not included.

	Long-term Control	Quick Relief	Education
STEP 4 Severe Persistent	Daily medications: • Anti-inflammatory: inhaled corticosteroid (high dose) AND • Long acting bronchodilator: either long acting inhaled $beta_2$ -agonist, sustained-release theophylline, or long acting $beta_2$ -agonist tablets AND • Corticosteroid tablets or syrup long term (make repeat attempts to reduce systemic steroids and maintain control with high dose inhaled steroids) *beclomethasone dipropionate*	• Short-acting bronchodilator: inhaled $beta_2$ -agonists as needed for symptoms. *albuterol* .	Steps 2 and 3 actions plus: • Refer to individual education/counseling
STEP 3 Moderate Persistent	Daily medication: • Either Anti-inflammatory: inhaled corticosteroid (medium dose) OR Inhaled corticosteroid (low-medium dose) and add a long acting bronchodilator, especially for nighttime symptoms; either long acting inhaled $beta_2$ -agonist, sustained-release theophylline, or long acting $beta_2$ -agonist tablets. *beclomethasone dipropionate*	• Short-acting bronchodilator: inhaled $beta_2$ -agonists as needed for symptoms. *albuterol*	Step 1 actions plus: • Teach self-monitoring • Refer to group education if available • Review and update self-management plan

Table IV.2-8: Stepwise Approach for Managing Asthma in Adults and Children Older than 5 Years of Age: Treatment
Adapted from NHLBI, 1997. Sections dealing with cautions are not included.

	Long-term Control	Quick Relief	Education
STEP 2 Mild Persistent	One daily medication: • Anti-inflammatory: either inhaled corticosteroid (low doses) or cromolyn or nedocromil (children usually begin with a trial of cromolyn or nedocromil). • Sustained-release theophylline to serum concentration of 5-15 mcg/mL is an alternative, but not preferred, therapy. Zafirlukast or zileuton may also be considered for patients ≥12 years of age, although their position in therapy is not fully established. *cromolyn*	• Short-acting bronchodilator: inhaled $beta_2$ -agonists as needed for symptoms. *albuterol.*	Step 1 actions plus: • Teach self-monitoring • Refer to group education if available • Review and update self-management plan
STEP 1 Mild Intermittent	• No daily medication needed.	• Short-acting bronchodilator: inhaled $beta_2$ -agonists as needed for symptoms. *albuterol*	• Teach basic facts about asthma • Teach inhaler/spacer/holding chamber technique • Discuss roles of medications • Develop self-management plan • Develop action plan for when and how to take rescue actions, especially for patients with a history of severe exacerbations • Discuss appropriate environmental control measures to avoid exposure to known allergens and irritants
Step down Review treatment every 1 to 6 months; a gradual stepwise reduction in treatment may be possible.		**Step up** If control is not maintained, consider step up. First, review patient medication technique, adherence, and environmental control (avoidance of allergens or other factors that contribute to asthma severity).	

Table IV.2-8: Stepwise Approach for Managing Asthma in Adults and Children Older than 5 Years of Age: Treatment
Adapted from NHLBI, 1997. Sections dealing with cautions are not included.

	Long-term Control	Quick Relief	Education

NOTE:

- The stepwise approach presents general guidelines to assist clinical decision making; it is not intended to be a specific prescription. Asthma is highly variable; clinicians should tailor specific medication plans to the needs and circumstances of individual patients.
- Gain control as quickly as possible; then decrease treatment to the least medication necessary to maintain control. Gaining control may be accomplished by either starting treatment at the step most appropriate to the initial severity of the condition, or starting at a higher level of therapy (e.g., a course of systemic corticosteroids or higher dose of inhaled corticosteroids).
- A rescue course of systemic corticosteroids may be needed at any time and at any step.
- Some patients with intermittent asthma experience severe and life-threatening exacerbations separated by long periods of normal lung function and no symptoms. This may be especially common with exacerbations provoked by respiratory infections. A short course of systemic corticosteroids is recommended.
- At each step, patients should control their environment to avoid or control factors that make their asthma worse (e.g., allergens, irritants); this requires specific diagnosis and education.
- Referral to an asthma specialist for consultation or co-management is recommended if there are difficulties achieving or maintaining control of asthma or if the patient requires step 4 care. Referral may be considered if the patient requires step 3 care.

The tables list drug options for each severity category. Data were not available on which drugs, of the many options, were actually used by a specific percentage of patients. Consequently, drugs were selected for purposes of cost estimation in this analysis because they were referred to or recommended frequently in the literature reviewed for this work. The selected drugs are listed in italics following each recommendation in the tables. Specific drug options in each drug category (e.g., beta2- agonists) are shown in Appendix IV.2-B with recommended doses for different ages and weights.

Some drugs are specified as "if needed" by NHLBI. Because they are not prescribed for all patients and information is lacking on the percentage of patients receiving these discretionary drugs, it was assumed that they were not prescribed for the average patient and they are not listed in the tables.[19] This is a cost-conservative assumption.

IV.2.B.3.2 Long-term Management for the High-use Patient

Patients who are not in compliance with NHLBI guidelines or other management plans are likely to spend less effort and money "managing" their disease through long-term drug therapy, and have a higher frequency of emergency room visits, hospitalizations, and sick visits to doctors' offices or clinics. Although actual practices are not well documented nor known at the national level, a number of studies have been carried out to evaluate specific intervention programs for "high-use" patients. These studies indicate that the frequency of visits to emergency rooms, hospitals, and doctors' offices or clinics to treat acute episodes can be substantially greater than for the average asthmatic. Some of these study results were summarized in Tables IV.2-2 and IV.2-3.

Link to Tables IV.2-2
Link to Table IV.2-3

IV.2.B.3.2.1 Office Visits

Two of the studies listed in Table IV.2-3 above (Higgins et al., 1998; and Westley et al., 1997) examined the rate of office visits among "high-use" patients before and after an intervention program. These studies suggest that the frequency of visits to doctors' offices or clinics among these "high-use" patients may be substantially greater than the frequency for the average asthmatic. The average frequency of visits (averaged over the two studies) was almost five times the frequency for the average asthmatic (3.491 per year versus 0.707 per year). Based on this information, the hypothetical high-use patient is estimated to visit a physician's office (or outpatient clinic) 3.491 times per year. Although these visits are listed under "long-term management" they are likely to be used mainly to address short-term medical needs rather than for checkups, planning, or education,

[19] Refer to NHLBI for additional information on these medications and recommendations.

due to the nature of the asthma management approach taken by these patients and their caregivers. The proportion of each type of office visit is not known.

IV.2.B.3.2.2 Drug Therapies

As discussed above, NHLBI guidelines regarding drug therapy are used for estimating treatment and costs for all asthma patients. Section IV.2.B.3.1.2 above provides details on drug therapy, and additional detail is provided in Appendix IV.2-B. Patients who are not in compliance with NHLBI guidelines are expected to use medication when they experience symptoms rather than use long-term management. Those who do not use long-term care drugs are likely to need a greater amount of short-term relief medications. There is not sufficient information in the literature to quantitatively determine the trade-offs in drugs used or costs incurred. Given the lack of data and the likelihood that underuse of preventive medication will result in greater use of short-acting medications, this analysis assumes that drug costs do not differ substantially among patients with different management strategies (although office visits, hospitalization, and emergency room use differ, as discussed below).

Link to Section IV.2.B.3.1.2

IV.2.B.4 Acute Care

IV.2.B.4.1 Acute Care for the Average Patient

IV.2.B.4.1.1 Emergency Room Visits

As discussed above, emergency room visits result when asthma episodes cannot be managed by the patient or family members sufficiently well to provide relief to the patient. The patient may be experiencing a life-threatening episode, or a relatively mild episode on arrival to the emergency room. Care will therefore vary widely. As discussed in Section IV.2.A, the likelihood of an asthma patient vising an emergency room is 0.117 annually. The procedures anticipated to occur, based on the 1991 physicians panel and NHLBI guidelines, are shown in Table IV.2-9. The emergency room services are not assume to be related to severity category because mild or severe exacerbations can occur among asthma patients in any severity category (NHLBI, 1997).

Table IV.2-9: Services provided in Hospitals to Asthma Patients
Chest X-Ray, 2 Views
Assay for Theophylline
Blood Gases: pH, pO2, pCO2
Automated Hemogram
IV Infusion Therapy, 1 Hour
Breathing Capacity Test
Airway Inhalation Treatment
ER Visit, Level 5
Drawing Blood for Specimen

IV.2.B.4.1.2 Hospitalization

Hospitalization occurs when the patient requires care beyond what can be provided in the emergency room — either specific therapies or observation and care that requires a longer period to provide. As discussed in Section IV.2.A, the likelihood of an average asthma patient being hospitalized is 0.034 annually. Hospital cost reimbursements are specified by Medicare, based on the patient's diagnosis in a diagnostically related group (DRG). This system is used widely by many medical cost reimbursement systems. Due to the use of this system, it is not necessary to list specific services provided in the hospital to estimate the costs of hospitalization, and they are not described in this analysis.

IV.2.B.4.2 Acute Care for High-use Patients

Failure to properly manage relatively severe asthma results in a much greater occurrence of acute episodes and greater utilization of more expensive acute care facilities. Utilization rates of acute care facilities (i.e., emergency rooms and hospitals) among "high-use" asthmatics can be many times the rates among the general population of asthmatics. Using the average of the "before intervention" rates in the studies listed in Table IV.2-3, the average rate of hospitalization in this group was estimated to be over 20 times the average rate among all asthmatics (0.732 per patient per year versus 0.034 per patient per year). The average rate of emergency room visits was estimated to be 1.663 per patient per year, over ten times the rate in the general population of asthmatics of 0.117. These higher values are used in the cost analysis below to estimate the annual and lifetime costs for the hypothetical high-use patient.

Link to Table IV.2-3

IV.2.B.5 Annual Cost of Treatment and Services

IV.2.B.5.1 Overview

The goal of this analysis is to determine the lifetime incremental direct medical cost of asthma. This section aggregates the annual costs for the following:

- office visits,
- drug therapy,
- emergency room care, and
- hospitalization.

The cost of diagnosis is also described, although that is incurred only once, rather than annually.

The medical costs are estimated for the average patient and for hypothetical high-use patients. Most costs for treatments and services were estimated using the Medicare reimbursements system. This system provides support for care for the elderly and the disabled. Consequently, recipients span all ages. There are specific reimbursements for many services for children (ages 0 to 17), which are used in this analysis. Medicare reimbursements charges generally fall between Medicaid reimbursement and self-pay or private insurance reimbursement. The use of Medicare data has both advantages and disadvantages, discussed in Chapter I.1.

Link to Chapter I.1

Although the arguments for and against using Medicare data to estimate costs are complex, these data are used in this case primarily because they are national cost data that have been judged, for this application, to be a reasonable proxy for the direct medical costs of services for asthma. Medicare payments are thought to be reasonably representative of the national costs of medical care because the Medicare program is the largest national payer for health care services. The Health Care Financing Administration (HCFA), which administers the Medicare program, has conducted a considerable amount of research into the actual resource costs of providing medical services, and has used this research in establishing Medicare payment rates. Moreover, Medicare payment methodologies and payment rates are often used by private payers and state Medicaid programs as a starting point in establishing their own methodologies and rates, and Medicare payment rates usually fall somewhere between Medicaid payment rates and private payer payment rates. Finally, data regarding Medicare payment rates are readily available from HCFA.

The services described for diagnosis, long-term management and management of acute episodes were mapped to actual CPT/HCPCS codes, which are used by the Medicare program to identify and pay for physician services and outpatient services.[20] Hospital costs are based on the admitting diagnosis and any subsequent diagnoses.

IV.2.B.5.2 Costs of Diagnosis

The cost of diagnosis is assumed to be the same for all patients and to occur only once during a lifetime. It was assumed that diagnosis occurred in a physician's office for this analysis. Diagnosis can also occur in an emergency room, which may lead to higher costs. Those costs would be best represented by the emergency room costs discussed in the next section. As discussed above, emergency room care usually does not rely on previous medical diagnosis and care; the patient goes through essentially the same procedures as diagnosis of a new case of asthma.

Medicare payment for most services provided in a physician's office is determined under the Medicare physician fee schedule. One exception to the Medicare physician fee schedule is made for clinical laboratory services, for which payments are determined under a separate fee schedule. Both the Medicare physician fee schedule and the Medicare clinical laboratory fee schedule used for the purposes of this analysis are effective for Calendar Year 1999. The treatments and services discussed above are included in Table IV.2-10 below, with relevant codes to link to Medicare's reimbursement system.

[20] The services identified in the tables represent one possible treatment profile. Actual practice patterns are variable across physicians, across specialties, and even across geographic areas. The cost estimates provided in the following tables should therefore be regarded with an understanding of this limitation.

Table IV.2-10: Costs of Diagnosis					
CPT Code	CPT Description	Source	1999 RVUs	1999 Physician Conversion Factor	1999 Medicare Payment
71020	Chest X-Ray, Two Views	Physician Fee	1.00	$34.73	$34.73
82803	Blood Gases: pH, pO2,	Clinical Lab Fee			$26.74
85025	Automated Hemogram	Clinical Lab Fee			$10.74
94010	Breathing Capacity Test	Physician Fee	0.88	$34.73	$30.56
99205	Office Visit, Level 5, New	Physician Fee	4.00	$34.73	$138.93
G0001	Drawing Blood for	Carrier Manual			$3.00
Total					$244.70

Under the Medicare physician fee schedule, the payment for a given service is determined using relative value units (RVUs), geographic practice cost indices (GPCIs), and a conversion factor (CF). RVUs measure the relative time, effort, and expense that physicians incur when providing services. The Resource Based Relative Value Scale (RBRVS) used by HCFA for the Medicare program expresses the RVUs for all services on a single scale. Under the RBRVS, there are separate RVUs for physician work (PW), practice expense (PE), and malpractice expense (ME). GPCIs are used to adjust RVUs for regional cost variations. There are separate GPCIs for physician work, practice expense, and malpractice expense RVUs. Finally, a CF quantifies the dollar value of one relative value unit and converts the RVUs associated with each service into a fee amount. Hence, the general formula for determining payment under the Medicare physician fee schedule for a given service is expressed as follows:

$$\text{Allowed Charge} = [(RVU_{PW} \times GPCI_{PW}) + (RVU_{PE} \times GPCI_{PE}) + (RVU_{ME} \times GPCI_{ME})] \times CF$$

As shown in Table IV.2-10, the 1999 Medicare payment for CPT codes 99203, 99204, 99205, 71020, and 94010 are determined under the Medicare physician fee schedule. CPT codes 99203, 99204, and 99205 describe office visits of increasing complexity for new patients; CPT code 71020 describes a two view chest X-ray; and CPT code 94010 describes spirometry, a breathing capacity test. National cost estimates were developed in this analysis; the GPCIs were not used to adjust the RVUs for these services. The 1999 Medicare payment for CPT codes 82803 (arterial blood gases) and 85025 (an automated complete blood count) are determined under the Medicare clinical laboratory fee schedule. Again, national cost estimates were developed, so the national limits under the Medicare clinical laboratory fee schedule were used in Table IV.2-10.

Finally, there is a nominal payment for HCPCS code G0001, routine venipuncture. The total Medicare payment for a patient diagnosed in the physician's office with asthma is $244.70 for the initial visit.

As discussed above, there is a second visit to confirm that the management plan is working properly. This visit is assumed to involve the same diagnostic procedures. Like the initial visit it involves time to discuss issues with the patient and do additional training. Consequently, the cost of this second visit is assumed to be the same as for the first visit. The total cost of diagnosis for patients who do not see a specialist is estimated as the cost of two visits, which equals $489.40.

As discussed in Section IV.2.B.2.5, 52.5 percent of all patients are assumed to be referred to a specialist during the initial diagnostic process. This referral will add a single additional office visit to the cost above for 52.5 percent of patients. This yields a total cost of:

$244.70 × 2 + .525 ($244.70) = $617.87

The average total cost for diagnosis is estimated to be $617.87

Link to Section IV.2.B.2.5

There are likely to be drugs provided by the physician at the time of diagnosis. Those costs are incorporated into the drug therapy costs discussed below under long-term management.

V.2.B.5.3 Cost for the Average Patient

IV.2.B.5.3.1 Office Visits

Table IV.2-11 provides the 1999 Medicare payment for follow-up care provided in a physician's office for patients with mild asthma, moderate asthma, and severe asthma. As discussed earlier, the Medicare payment for services provided in a physician's office is determined by the Medicare physician fee schedule and the Medicare clinical laboratory fee schedule.

As shown in Table IV.2-11, the 1999 Medicare payment for CPT codes 99215, 71020, and 94010 are determined under the Medicare physician fee schedule. CPT code 99215 describes an office visit of level 5 for established patients; CPT code 71020 describes a two-view chest X-ray; and CPT code 94010 describes spirometry, a breathing capacity test. The 1999 Medicare payment for CPT code 80198 (assay for theophylline) is determined under the Medicare clinical laboratory fee schedule. The national limit under the Medicare clinical laboratory fee schedule was used in Table IV.2-11. Finally, there is a nominal payment for HCPCS code G0001, routine venipuncture.

Table IV.2-11: Asthma: Cost of Office Visit					
CPT Code	CPT Description	Source	1999 Medicare RVUs	1999 Medicare Conversion Factor	1999 Medicare Payment
71020	Chest X-Ray, Two Views	Physician Fee	1.00	$34.74	$34.74
80198	Assay for Theophylline	Clinical Lab Fee Schedule			$19.56
94010	Breathing Capacity Test	Physician Fee	0.88	$34.73	$30.56
99215	Office Visit, Level 5, Established Patient	Physician Fee Schedule	2.82	$34.73	$97.94
G0001	Drawing Blood for Specimen				$3.00
					$185.80

The total Medicare payment for follow-up care provided in a physician's office to a patient with asthma is estimated to be $185.80. ***Using the average patient rate of 0.707 visits per year, the average annual cost of office visits per patient is estimated to be $131.36.***

IV.B.5.3.2 Cost of Drug Therapy

As discussed previously, the NHLBI recommends specific drug therapies for children five years and younger and for those older than five, for each severity category. These therapies were listed in Tables IV.2-5 and IV.2-6 in Section IV.2.B.3 above. As discussed in that section, data were not available on which drugs were actually used by a specific percentage of patients, so drugs were selected from the numerous options that were referred to or recommended frequently in the literature reviewed for this work. The selected drugs are listed in italics following each recommendation in the above-cited tables.[21]

Link to Table IV.2-5
Link to Table IV.2-6

The selected drugs are listed in Table IV.2-12 with the dose and frequency of use. Their use is then converted to units (e.g., one inhaler) and the unit cost is listed, followed by the annual cost. The final column contains the weighted cost calculated as the percentage of patients in the severity category (listed in column 1) times the annual cost.

Drug costs were taken from the 1998 Red Book, a reference book used by the pharmacies to obtain prices (Red Book, 1998). The relationship between pharmaceutical average wholesale prices (AWP) cited in the Red

[21] Specific drug options in each drug category (e.g., beta-2 agonists) are shown in Appendix IV.2-B with recommended doses for different ages and weights.

Book and the average retail price has fluctuated dramatically over the last few years. Historically, retail prices were based on a percentage markup over wholesale prices. In some cases, however, the Red Book AWP actually exceeds retail rates. A quick review of prices charged by national pharmacy chains for the most common asthma medications indicated that Red Book prices are very close to those charged by the chains. There are numerous companies marketing the most common drugs, and their prices vary somewhat.

For this analysis, an average cost was estimated by reviewing the spectrum of costs listed in the Red Book . When the HCFA price was provided and it was lower than the average price (e.g., in the case of albuterol tablets) that price was used. (The HFCA price is the maximum price limit determined for payment by the federal government.) When prices were provided for various sizes of packaging, the largest size, which was invariably the least expensive, was used to estimate costs. These prices are likely to vary over time as new products are introduced and market forces continue to play a role in pricing.

Drug therapy costs differ for the youngest patients (ages four and five), and older patients, as shown in the table above. The drug costs per year for each age are used in the lifetime cost analysis, based on the costs incurred at each specific age.

Additional information, not used in the lifetime cost analysis on the average annual cost across all ages, is provided here. The average cost per patient was calculated as a weighted average cost per year. If diagnosis occurs at age four (the average age of diagnosis) and the patient has asthma throughout his or her life (through age 75), then the full lifespan of the disease is 72 years. Two of those years are at the lower cost for drug therapy of $471.40, and 70 are at the higher cost of $615.14. The average annual cost per patient is calculated as:

$$[2 \times \$471.40 + 70 \times \$615.14] / 72 = \$611.15$$

Table IV.2-12: Drug Costs for Asthma Therapy: Long-term and Acute Management (Adapted from NHLBI, 1997. Additional detail provided in Tables IV.2-5 and 6 above.)							
Severity (% in Category)	**Drugs**	**Dose**	**Frequency**	**Units per Year**	**Cost per Unit in $**	**Annual Cost in $**	**Proportional Annual Cost (cost * % in category)**
Children age 5 and under							
1 (35%)	albuterol	2 puffs	2 × /week	1 inhaler	25	25	8.75
2 (35%)	albuterol	2 puffs	2 × /week	1 inhaler	25	25	8.75
	cromolyn	2 puffs	1 × /day	3.7 inhalers	70	259	90.65
3 (25%)	albuterol	2 puffs	3 s /day	10.95 inhalers	25	274	68.50
	beclomethasone dipropionate	8 - 16 puffs (assume 12)	over the day	21.9 inhalers	40	876	219.00
4 (5%)	albuterol	2 puffs	3 × /day	10.95 inhalers	25	274	13.70
	beclomethasone dipropionate	> 16 puffs (assume 17)	over the day	31.03 inhalers	40	1241	62.05
Total Annual Average Cost : $471.40							
Children Over age 5 and Adults							
1 (35%)	albuterol	2 puffs	2 × /week	1 inhaler	25	25	8.75
2 (35%)	albuterol	2 puffs	2 × / week	1 inhaler	25	25	8.75
	cromolyn	2 puffs	1 × /day	3.7 inhalers	70	259	90.65
3(25%)	albuterol	2 puffs	3 × /day	10.95 inhalers	25	274	68.50
	beclomethasone dipropionate	12 - 20 puffs (assume 16)	over the day	29.2 inhalers	40	1168	292.00
4(5%)	albuterol	2 puffs	3 × /day	10.95 inhalers	25	274	13.70
	beclomethasone dipropionate	>20 (assume 21)	over the day	38.33 inhalers	40	1533	76.66
	methyl prednisolone	24 mg/day = 6 tablets	over the day	2190 tablets	.50	1095	54.75
	albuterol	4 mg tablets	2 × /day	730 tablets	.0378	28	1.38
Total Average Annual Cost: $615.14							
Cost for both age groups, assuming age of diagnosis of four years (at beginning of year) and death at age 75.							

In addition to the cost of drugs discussed above, patients with severe asthma are urged to have a nebulizer at home as part of their asthma therapy. A nebulizer costs approximately $80.00, and comes with a five-year warranty, yielding an annual cost of approximately $16.00. This cost is assumed to be applicable only to the five percent of patients who are estimated to have severe asthma. The average cost per patient is therefore estimated to be 16 × 0.05 = $0.80. This cost is added to the annual drug cost listed in Table 2-12, yielding a total annual average cost of $472.20 for children under 5 years of age and $615.94 for children five and over and for adults.

Using the assumptions and sources above, the estimated drug therapy cost for the average asthma patient is $611.95.

When lifetime costs are calculated, the stream of costs incurred each year is summed. The costs for ages four and five 4 and 5 are added to the costs for ages 6 through 75, yielding the same average annual cost. This analysis also provides discounted costs (at three, five, and seven percent). When costs are discounted, the average annual cost will differ slightly because the discounting applied to later years yields much lower costs than those incurred in the current or proximal years.

IV.2.B.5.3.3 Costs of Emergency Room Care for the Average Patient

Currently, Medicare payment for outpatient hospital services is determined under multiple methodologies. For example, payment for ambulatory surgical services is determined on the basis of a blend of aggregate hospital outpatient costs and the ambulatory surgical center (ASC) payment methodology, while payment for diagnostic radiology services is determined on the basis of a blend of aggregate hospital outpatient costs and the Medicare physician fee schedule. Medicare payments for most outpatient hospital services are based in part on aggregate hospital outpatient costs; payment rates for individual outpatient services do not exist.

Beginning in 2000, however, Medicare payment for most outpatient hospital services will be determined using a prospective payment system (PPS) based on Ambulatory Payment Classification (APC) groups. A proposed rule for this system was published in the September 8, 1998 *Federal Register* and revised in the June 30, 1999 *Federal Register*. We used these proposed payment rates to develop the cost estimates provided in Table IV.2-8 because the proposed Medicare hospital outpatient PPS assigns payment rates to individual outpatient services. Once again, however, clinical laboratory services will be exempt from the proposed PPS and will continue to be paid under the Medicare clinical laboratory fee schedule. It also should be noted that the proposed PPS applies only to the

facility fee paid to a hospital. Professional services provided by physicians will therefore continue to be paid under the Medicare physician fee schedule.

Link to Table IV.2-8

Under the proposed PPS, each service provided in a hospital outpatient department will be assigned to an APC. An APC represents a group of services with similar resource requirements and clinical characteristics. The payment for the service will be determined as the product of the relative weight for the APC group to which the service is assigned and a CF. The labor-related portion of the CF will be adjusted by the Medicare wage index for inpatient hospital services based on the metropolitan statistical area in which the hospital is located. We did not adjust the national standardized operating amounts because we are developing national cost estimates. Although the proposed PPS will become effective sometime in 2000, the proposed CF published in the *Federal Register* is expressed in 1999 dollars.

Table IV.2-13 provides the 1999 Medicare payment for treating patients with asthma in a hospital emergency room. As shown in Table IV.2-5, the 1999 Medicare payment for CPT codes 99283, 99284, 99285, 90780, 94640, and 71020-TC are determined under the Medicare hospital outpatient PPS. CPT codes 99283, 99284, and 99285 describe emergency department visits of increasing complexity, CPT code 90780 describes one hour of IV infusion therapy, CPT code 94640 describes nebulizer therapy, and CPT code 71020-TC describes the technical component of a two-view chest X-ray. The 1999 Medicare payment for the physician's interpretation of the X-ray (71020-26) is determined under the Medicare physician fee schedule, and the 1999 Medicare payment for CPT codes 80198 (assay for theophylline), 82803 (arterial blood gases), and 85025 (automated complete blood differential) are determined under the Medicare clinical laboratory fee schedule. Finally, there is no payment for HCPCS code G0001 in a hospital setting. The total Medicare payment for a patient diagnosed in a hospital emergency room with asthma is $442.84**.** The average patient uses an emergency room 0.117 times per year**.** ***This yields an average annual cost of $51.81 per patient for emergency room visits.***

Link to Table IV.2-5

Table IV.2-13: Cost of Emergency Room Care

Procedure	CPT Code	CPT Description	Status	Source	APC	APC Description	Proposed APC Relative Weight	Proposed APC Conversion Factor	1999 RVUs	1999 Physician Conversion Factor	1999 Medicare Payment
Chest Radiological Examination	71020-PC	Chest X-Ray, 2 Views, Professional		Physician Fee Schedule					0.33	$34.73	$11.00
Routine Venipuncture	71020-TC	Chest X-Ray, 2 Views, Technical	X	Hospital Outpatient PPS	700	Plain Film	0.80	$51.42			$41.00
Blood Gas Oximetry	80198	Assay for Theophylline	A	Clinical Lab Fee Schedule							$19.56
Blood Theophylline	82803	Blood Gases: pH, pO2, pCO2	A	Clinical Lab Fee Schedule							$26.74
Spirometry	85025	Automated Hemogram	A	Clinical Lab Fee Schedule							$10.74
Complete Blood Count	90780	IV Infusion Therapy, 1 Hour	X	Hospital Outpatient PPS	906	Infusion Therapy Except Chemo	1.93	$51.42			$99.00
Emergency Room Charge	94010	Breathing Capacity Test	X	Hospital Outpatient PPS	971	Level I Pulmonary Tests	0.98	$51.42			$50.00
Theophylline IV	94640	Airway Inhalation Treatment	S	Hospital Outpatient PPS	976	Pulmonary Therapy	0.44	$51.42			$23.00
Nebulizer Therapy	99285	ER Visit, Level 5	V	Hospital Outpatient PPS	95533	High Level ER Visits/Respiratory	3.13	$51.42			$161.00
Physician Charge	G0001	Drawing Blood for Specimen	A	Not Paid in Hospital							$0.00
Total											$442.84

IV.2.B.5.3.4 Cost of Inpatient Hospital Care for the Average Patient

Hospitalization costs are determined by the specific diagnosis that is provided for the patient. The standard form of these diagnoses is the International Classification of Disease codes: ICD-9. Medicare payment for inpatient hospital services is determined under the Medicare hospital inpatient prospective payment system. Under this system, reimbursement is based on the principal and secondary ICD-9-CM diagnosis and procedure codes, and the age and sex of the patient.

1999 Medicare payment reimbursement values are provided for hospital patients with the following principal ICD-9-CM diagnoses:

493.00—Extrinsic Asthma Without Status Asthmaticus
493.01—Extrinsic Asthma With Status Asthmaticus
493.10—Intrinsic Asthma Without Status Asthmaticus
493.11—Intrinsic Asthma With Status Asthmaticus
493.90—Unspecified Asthma Without Status Asthmaticus
493.91—Unspecified Asthma With Status Asthmaticus

There are three DRGs for patients diagnosed with asthma:

DRG 96—Bronchitis & Asthma Age > 17 With Complications
DRG 97—Bronchitis & Asthma Age > 17 Without Complications
DRG 98—Bronchitis & Asthma Age 0-17

Information was not available on the percentage of patients admitted with asthma complications that are directly related to asthma. Those that are unrelated would not have costs attributable to asthma. For this analysis, it is assumed that "asthma without complications" as listed above is relevant (DRG 96). Costs for DRG 97 are provided to demonstrate the cost range that may occur with complications. For children (ages 0 to 17) the Medicare reimbursement system does not make a distinction between patients with and without complications.

As shown above, the reimbursements also differ for children (ages 0 to 17) and adults. The distribution of hospitalizations between children and adults was estimated using the data from CDC (1998a) regarding the number of hospitalizations for different age groups for the years 1993-1994. The percentage of hospital visits made by children (through age 17) was 37.71 percent (rounded to 38 percent), with the balance of admissions for adults (62 percent).

Generally, payment is determined as the product of the relative weight for the DRG to which the patient is assigned and a national standardized operating and capital amount. There are separate national standardized operating amounts for large urban areas and other areas. The labor-related portion of the national standardized operating amount is usually adjusted

by the Medicare wage index for inpatient hospital services, based on the MSA in which the hospital is located. We did not adjust the national standardized operating amounts because we are developing national cost estimates. Medicare does not provide a single national value, but instead provides two values, one for urban areas (metropolitan statistical areas) and one for non-urban areas. Although information is not available on the distribution of asthma hospitalizations geographically, the problem of asthma hospitalizations in urban areas is well-recognized. The values for urban hospitals are therefore used in this analysis.

Table IV.2-14 lists the 1999 Medicare payment for a patient assigned to DRGs 96, 97, or 98 as $3,531.13, $2,648.68, or $3,111.38, respectively, in large urban areas; and $3,338.59, $2,504.26, or $2,941.73, respectively, in other areas. Using the urban area values, an age-weighted cost based on the percentage distribution discussed above can be calculated:

38% × $3111,38 + 62% × $2648.68 = $2824.50.

The average hospitalization cost is estimated to be $2,824.50. This cost is combined with the average rate of hospitalizations for asthma patients of 0.034 per year to yield an ***estimated annual hospitalization cost of $99.43 per patient.***

Table IV.2-14: Asthma: Cost of Inpatient Hospital Care

DRG	DRG Description	ICD-9 Diagnosis Codes	DRG Relative Weight	National Standardized Operating Amount for Large Urban Areas	National Standardized Capital Amount	DRG Payment for Operating and Capital for Large Urban Areas	National Standardized Operating Amount for Other Areas	National Standardized Capital Amount	DRG Payment for Operating and Capital for Other Areas
96	Bronchitis & Asthma Age > 17 With Complications	493.00, 493.01, 493.10, 493.11, 493.90, 493.91	0.7891	$4,096.83	$378.05	$3,531.13	$3,852.83	$378.05	$3,338.59
97	Bronchitis & Asthma Age > 17 Without Complications	493.00, 493.01, 493.10, 493.11, 493.90, 493.91	0.5919	$4,096.83	$378.05	$2,648.68	$3,852.83	$378.05	$2,504.26
98	Bronchitis & Asthma Age 0-17	493.00, 493.01, 493.10, 493.11, 493.90, 493.91	0.6953	$4,096.83	$378.05	$3,111.38	$3,852.83	$378.05	$2,941.73

IV.2.B.5.3.5 Annual Costs for the Average Patient

The total annual medical costs for the average asthma patient sum the costs of office visits, drug therapy, emergency room use, and hospitalizations. These costs, as discussed in the text above, are summarized in Table IV.2-15. The are derived by multiplying the cost of each service times the rate of utilization per patient in a given year. Note that the costs for drug therapy and hospitalization change during childhood; the differing costs are presented at the end of the table.

IV.2-15: Summary of Average Annual Costs for the Average Patient (undiscounted)

Treatment and Service	Cost (1999$)*
Office Visits	131.36
Drug Therapy**: ages 4 and 5 ages 6 to 75	 472.20 615.94
Emergency Room Use:	51.81
Hospitalization: ages 4 to 17 ages 18 to 75	 105.79 90.06
Total: ages 4 to 5 ages 6 to 17 ages 18 to 75	 761.16 904.90 889.17

* The costs are as listed in previous tables The costs for all services are in 1999 dollars, based on Medicare reimbursement amounts. The drug costs are taken from the 1998 Red Book (Red Book, 1998) and were not adjusted because the CPI for this year is not yet available.

**Includes an average annual $0.80 for use of a nebulizer.

IV.2.B.5.4 Costs for the High-use Patient

The cost categories for the high-use patient are the same as those for the average patient: office visits, drug therapy, emergency room use, and hospitalizations. As discussed above, the annual cost of drug therapy for high-use patients is assumed to be the same as for the average patient, even though the actual use of specific drugs (long-term versus short-acting) is expected to differ. The cost of nebulizers are higher, on average, than for average patients, because the proportion of severe asthmatics in the high-use group is higher than among all asthmatics (1 in 6 versus 1 in 20). The annual average cost of a nebulizer, used only by severe asthmatics, is greater than for the average asthmatic ($2.66 per year, averaged over all high-use asthmatics, versus $0.80 per year averaged over all asthmatics), yielding an annual estimated drug cost of $474.06 for children ages four and five and $617.80 for those over age five.

The costs per service in the other categories (e.g., emergency room visit) are assumed to be the same for the average patient and for the high-use patient. The frequency of utilization of each type of service is different, as discussed above and as shown in Table IV.2-3. The costs of a hospitalization are calculated for two separate age categories (ages 0-17, and ages over 17), as are the costs of drug therapy (ages 4 and 5, and ages over 5). As discussed above, the annual cost in each category is derived by multiplying the cost of each service by the rate of utilization of the service (i.e., the average number of times the service is used per year per high-use patient). The utilization rates used in these calculations are given in Table IV.2-3. The total annual costs for the high-use patient are shown in Table IV.2-16.

Link to Table IV.2-3.

Table IV.2-16: Total Annual Costs for the High-use Asthma Patient

Treatment and Service	Cost (in 1999$)
Office Visits	648.66
Drug Therapy* ages 4 to 5 ages 6 to 75	 474.06 617.80
Emergency Room Use	736.45
Hospitalization ages 4 to 17 ages 18 to 75	 2,276.18 1,937.69
Total ages 4 -5 ages 6 to 17 ages 18 to 75	 4,135.35 4,279.09 3,940.60
*Includes an annual average $2.66 for use of a nebulizer.	

The costs for each age group among high-use patients are more than five times the corresponding costs for the average patients described in the previous section. This difference reflects the much higher use of expensive services, such as emergency rooms and hospitals, and the increased number of office visits.

IV.2.B.6. Summary of Lifetime Costs

Lifetime costs are those direct medical costs incurred by the patient from the average age of diagnosis of the disease (four years in this case) to the average age of death of 75 years. The medical costs relevant to each age were summed over the ages 4 to 75 to calculate the estimated lifetime direct medical costs.

As discussed in the prognosis section (Section IV.2.A.5), approximately 30 percent of asthma patients become asymptomatic as they move into adulthood. For this analysis it is assumed that these patients will not incur costs beyond their seventeenth year, although in practice there is a range of ages entering adulthood when people become asymptomatic. The remaining 70 percent of asthma patients are assumed to have the disease throughout their life. It is not assumed that high-use patients will go into asthma remission because : 1) they are based on a higher risk group (moderate and severe asthmatics), and 2) their disease has not been carefully managed (by definition) and their increased use of acute services indicates a higher number of asthma episodes. As discussed in Section IV.2.A, the repeated episodes that occur when asthma is not carefully managed are likely to lead to permanent adverse structural changes in the respiratory system, which is likely to cause this group to have a higher requirement for ongoing medical care.

Link to Section IV.2.A.5

The death rate among asthma patients in 1994 was 0.0004 per patient. Mortality from asthma occurs primarily among the elderly. The impact of deaths on costs is not considered in this analysis due to the very small percentage of patients who die of this disease, the advanced age at which people typically die of asthma (and therefore the very small reduction in cost associated with death), and the impact that discounting has in minimizing costs attributable many decades in the future.[22] Unfortunately, there are also deaths that occur among children and young adults. A precise age distribution is not available for asthma-associated deaths, and asthma mortality was not evaluated in this analysis due to its rarity.

Table IV.2-17 shows the lifetime costs estimated to occur for asthmatic patients both as an undiscounted cost and at discount rates of three, five, and seven percent.

Table IV.2-17: Lifetime Direct Medical Costs for Asthma (in 1999$)

Patient Category	Undiscounted	3%	5%	7%
Average patient	$49,099	$22,447	$15.974	$12.242
High-use Patients	$220,026	$101,459	$72,342	$56,411

[22] While the impact of mortality and an associated reduction in medical costs is small on an individual basis, there are a substantial number of deaths when the rate is considered in light of the entire asthmatic population. Consequently, it would be useful to consider the VSL with the mortality statistics if benefits evaluations were being carried out.

The undiscounted costs for the average patient are approximately $50,000 over the average lifespan. For the hypothetical high-use patient, the lifetime costs are approximately $220,000.

Data reviewed for this analysis suggest that high-use patients are likely to be people in lower socioeconomic groups, in urban areas, and often minorities. The need for acute care and the medical costs borne by these people is considerably higher than for the average asthmatic. Conversely, improvements in their disease management and reductions in the occurrence or severity of disease will result in substantial reductions in costs, as well a concurrent reduction in pain and suffering, disability, and lost school time. The sensitivity analysis that follows is an evaluation of the potential impacts on costs of interventions designed to improve asthma management.

IV.2.C. Sensitivity Analysis

Many aspects of this cost analysis for asthma could be considered in a sensitivity analysis. A single aspect has been selected for evaluation at this time (additional evaluations may be done at a future date).[23] As discussed previously, there are substantial costs associated with acute care required by patients who are not able to follow an optimal management plan for the disease. This difficulty in following an optimal plan may be due to the medical care provided, access to care, patient understanding, or other factors. Studies of service utilization among high-use patients cited in the preceding sections evaluated the impact of education and guidance designed to improve asthma management by patients. These interventions had a substantial impact on service utilization (as shown in Table IV.2-3 above). This sensitivity analysis considers the medical costs incurred by those patients after intervention. This analysis provides an alternative cost estimate for moderate and severely affected patients, as well as demonstrating the potential efficacy of programs that assist asthma patients in managing their disease.

Link to Table IV.2-3

The data from Table IV.2-3 were used as a source of utilizations rates, taking the average values across studies from the "after intervention" columns for office visits, emergency room visits, and hospitalizations. It was assumed that drug therapy costs would not change (although the use of specific drugs is likely to change).

[23] Numerous parameters that could be evaluated in a sensitivity analysis are presented in the Uncertainty Analysis section that follows (IV.2.D). Feedback is sought from reviewers on which specific parameters would be of interest. The calculation of costs is carried out through spreadsheets that can be modified easily for most parameters to evaluate sensitivity to altering assumptions and other inputs.

Table V.2-18: Total Annual Costs for the High-use Asthma Patient After Intervention	
Treatment and Service	**Cost (1999$)**
Office Visits	572.81
Drug Therapy* ages 4 to 5 ages 6 to 75	 474.06 617.80
Emergency Room Use	249.47
Hospitalization ages 4 to 17 ages 18 to 75	 624.41 531.55
Total ages 4 -5 ages 6 to 17 ages 18 to 75	 $1,920.75 $2,064.48 $1,971.63
*Includes an annual average $2.66 for use of a nebulizer	

Using the same approach as described above, the costs over the lifespan were summed to obtain an estimated total lifetime medical cost. The undiscounted value is $109,281**.** The various discounted costs are shown in Table IV.2-19 below.

Table IV.2-19: Lifetime Direct Medical Costs for Asthma Among High-use Patients After Intervention (in 1999$)				
Patient Category	**Undiscounted**	**3%**	**5%**	**7%**
High-use Patients After Intervention	$109,281	$50,041	$35,569	$27,678

As a comparison of Tables IV.2-18 and IV.2-19 shows, there is a substantial decrease in costs resulting from interventions that reduce the use of acute care medical services. There is an approximately $110,000 savings in lifetime medical costs using undiscounted medical cost estimates. Even using highly discounted values (at 7%) the savings is approximately $30,000.

Additional information on the specific methods used to improve patients' asthma management can be obtained from the five papers cited in Table IV.2-3.

Link to Table IV.2-3

IV.2.D Uncertainty Analysis

There are numerous sources of uncertainty in this cost analysis. They are discussed throughout the text as assumptions and inputs from various data sources (e.g., CDC reports). Because these are discussed in detail in the text, a detailed discussion of the sources of uncertainty is not duplicated in this section. The sources of uncertainty are summarized in Table IV.2.20. The table lists the nature of the uncertainty, the likely impact of the uncertainty on costs (leading to an over- or underestimate), and the location in the text where the issue was first discussed. In most cases, it is unknown whether the impact leads to an overestimate or underestimate of costs.

Table IV.2-20 Sources of Uncertainty in the Cost Estimates

Source of Uncertainty	Expected Impact	Location in Chapter
Prevalence and service use statistics from CDC — extrapolated from surveys	Unknown	IV.2.A.1.2
Use of services by high-use patients — based on five studies	Unknown	IV.2.A.1.11
Concurrent Effects Caused by Asthma — not quantitatively considered in cost analysis	Underestimate Costs	IV.2.A.2
Remission rate — may differ at this time.	Unknown	IV.2.A.5
Specific services provided to patients during diagnosis, office visits, emergency room use, and hospitalization — estimated from general statements in NHLBI and recommendations of 1991 panel	Unknown	IV.2.B.1.2.2
Assumed lifespan of 75 years — based on Exposure Factors Handbook and an assumption of minimal asthma mortality	Unknown	IV.2.B.2.3
Estimated age of diagnosis of four years	Unknown	IV.2.A.1.2
Infrequent diagnosis of asthma in children younger than one year of age — may impact estimated age of diagnosis	Underestimate	IV.2.B.2.1
Diagnostic tests that may be carried out but are not included in cost estimates	Underestimate	IV.2.B.2.2
Distribution of current asthma severity level in the population — based on 1991 panel recommendations	Underestimate	IV.2.B.2.3
Assumption that average and high-use patients' drug costs are represented by the profile of drug use recommended by NHLBI and the specific drugs selected for cost estimation	Unknown	IV.2.B.2.4

Table IV.2-20 Sources of Uncertainty in the Cost Estimates		
Source of Uncertainty	**Expected Impact**	**Location in Chapter**
Assumption that a specific percentage of patients are referred to a specialist and that they will see the specialist only once	Underestimate	IV.2.B.2.5
Assumption that costs associated with a visit to a specialist will be the same as an office visit, as specified	Underestimate	IV.2.B.2.5
Assumptions that a level 5 office visits is most relevant for diagnosis and follow-up care	Overestimate	IV.2.B.2.6
Assumption that the Medicare reimbursement system accurately represents average costs	Unknown	IV.2.B.5.2
Assumption that the severity of asthma over the lifespan doesn't change, except among 30% who become symptom-free.	Unknown	IV.2.B.
Assumptions regarding the proportion of high-use patients who have severe versus moderate asthma — used to estimate drug therapy costs and visits to specialists	Unknown	IV.2.B.5.3.2 — drug therapy IV.2.B.2.5 — referral to specialist

Of the sources listed above, some may have a larger impact than others *if* they deviate substantially from the actual experience of the national population of asthmatics. These generally include those assumptions or parameters that impact the costs across the board for most services of patients. They include the assumption that Medicare costs are relevant, the profile of services described for patients (including diagnostic tests), and the rate of office visits, emergency room visits, and hospitalizations per asthmatic.

The uncertainties described above have either an unknown impact, or, in most cases, tend to underestimate costs (or have an unknown impact). Consequently, this cost estimate should be considered a lower-bound estimate of costs for the average patient.

APPENDIX IV.2-A. CHEMICALS ASSOCIATED WITH ASTHMA

The toxic chemicals listed in this appendix are a sample of the potential environmental hazards associated with this diseases (the chemicals with asterisks are subject to reporting requirements under the Toxics Release Inventory, Section 313 of the Emergency Planning and Community Right-to-Know Act). Although the tables contain many chemicals associated with the disease, the list is incomplete for two reasons:

1. It does not include toxicological data from sources other than HSDB through 1996. The toxicological literature currently available is vast, and a thorough review was beyond the scope of this analysis.

2. The human health effects of many environmental hazards are unknown, especially at concentrations found in the environment.

For these reasons, Table IV.2.A-1 should not be used as a definitive source of information on the links between chemical hazards and asthma. Rather, further research should be done by analysts using this handbook to identify the dose-response relationships between the chemical hazards of concern and the diseases.

Table IV.2.A-1: Chemicals Associated with Asthma in the Hazardous Substances Data Bank (HSDB) Human Toxicity Excerpts (metal compounds are assumed to have characteristics of parent element)

CAS Number	HSDB Entry Revision	Chemical name
811-97-2	2/1/96	1,1,1,2-TETRAFLUOROETHANE
1717-00-6	2/1/96	1,1-DICHLORO-1-FLUOROETHANE*
124-73-2	6/27/96	1,2-DIBROMOTETRAFLUOROETHANE*
76-14-2	6/7/96	1,2-DICHLORO-1,1,2,2-TETRAFLUOROETHANE*
1649-08-7	2/1/96	1,2-DICHLORO-1,1-DIFLUOROETHANE*
624-72-6	2/1/96	1,2-DIFLUOROETHANE
106-50-3	6/24/96	1,4-BENZENEDIAMINE
16245-77-5	1/31/96	1,4-BENZENEDIAMINE SULFATE
762-49-2	2/1/96	1-BROMO-2-FLUOROETHANE
75-68-3	1/26/96	1-CHLORO-1,1-DIFLUOROETHANE*
762-50-5	2/1/96	1-CHLORO-2-FLUOROETHANE
306-83-2	6/7/96	2,2-DICHLORO-1,1,1-TRIFLUOROETHANE*
137-09-7	1/28/96	2,4-DIAMINOPHENOL DIHYDROCHLORIDE
584-84-9	6/11/96	2,4-TOLUENE DIISOCYANATE*
823-40-5	1/27/96	2,6-DIAMINOTOLUENE*
95-55-6	1/27/96	2-AMINOPHENOL

Table IV.2.A-1: Chemicals Associated with Asthma in the Hazardous Substances Data Bank (HSDB) Human Toxicity Excerpts (metal compounds are assumed to have characteristics of parent element)		
CAS Number	**HSDB Entry Revision**	**Chemical name**
151-67-7	5/17/96	2-BROMO-2-CHLORO-1,1,1-TRIFLUOROETHANE
2837-89-0	6/7/96	2-CHLORO-1,1,1,2-TETRAFLUOROETHANE*
496-72-0	1/31/96	3,4-DIAMINOTOLUENE
591-27-5	1/24/96	3-AMINOPHENOL
9000-01-5	1/23/96	ACACIA
37517-30-9	2/1/96	ACEBUTOLOL
315-30-0	6/6/96	ALLOPURINOL
10043-67-1	6/21/96	ALUM, POTASSIUM
7429-90-5	6/21/96	ALUMINUM*
7784-25-0	6/21/96	ALUMINUM AMMONIUM SULFATE
7727-15-3	6/21/96	ALUMINUM BROMIDE
1344-01-0	5/14/96	ALUMINUM CALCIUM SODIUM SILICATE
7446-70-0	3/21/96	ALUMINUM CHLORIDE
7784-18-1	6/21/96	ALUMINUM FLUORIDE
21645-51-2	6/6/96	ALUMINUM HYDROXIDE
13473-90-0	6/21/96	ALUMINUM NITRATE
1344-28-1	6/21/96	ALUMINUM OXIDE*
20859-73-8	3/21/96	ALUMINUM PHOSPHIDE*
15096-52-3	6/24/96	ALUMINUM SODIUM FLUORIDE
10102-71-3	6/21/96	ALUMINUM SODIUM SULFATE
10043-01-3	6/21/96	ALUMINUM SULFATE
1951-25-3	5/14/96	AMIODARONE
16919-58-7	5/10/96	AMMONIUM CHLOROPLATINATE
26787-78-0	7/11/96	AMOXICILLIN
69-53-4	7/11/96	AMPICILLIN
77-02-1	1/26/96	APROBARBITAL
68844-77-9	2/1/96	ASTEMIZOLE
1302-78-9	7/11/96	BENTONITE
65-85-0	3/21/96	BENZOIC ACID
353-59-3	4/18/96	BROMOCHLORODIFLUOROMETHANE*
75-63-8	6/11/96	BROMOTRIFLUOROMETHANE*
125-40-6	6/6/96	BUTABARBITAL
2611-82-7	5/14/96	C..I ACID RED 18
4697-36-3	7/11/96	CARBENICILLIN
25953-19-9	7/11/96	CEFAZOLIN
15686-71-2	7/11/96	CEPHALEXIN
76-15-3	7/22/96	CHLOROPENTAFLUOROETHANE
63938-10-3	8/14/95	CHLOROTETRAFLUOROETHANE*
7738-94-5	6/18/96	CHROMIC ACID
10101-53-8	6/18/96	CHROMIC SULFATE
1308-31-2	6/3/96	CHROMITE
25402-06-6	5/14/96	CINERIN I
121-20-0	5/14/96	CINERIN II

Table IV.2.A-1: Chemicals Associated with Asthma in the Hazardous Substances Data Bank (HSDB) Human Toxicity Excerpts (metal compounds are assumed to have characteristics of parent element)		
CAS Number	**HSDB Entry Revision**	**Chemical name**
15663-27-1	5/13/96	CIS-DIAMINEDICHLOROPLATINUM
61-72-3	7/11/96	CLOXACILLIN
7440-48-4	6/21/96	COBALT*
13426-91-0	5/3/96	CUPRIETHYLENEDIAMINE
973-21-7	1/21/96	DESSIN
334-88-3	6/24/96	DIAZOMETHANE*
90454-18-5	6/7/96	DICHLORO-1,1,2-TRIFLUOROETHANE*
75-71-8	5/9/96	DICHLORODIFLUOROMETHANE*
34077-87-7	6/7/96	DICHLOROTRIFLUOROETHANE*
3116-76-5	7/11/96	DICLOXACILLIN
2425-06-1	4/23/96	DIFOLATAN
75847-73-3	5/14/96	ENALAPRIL
51-79-6	5/11/96	ETHYL CARBAMATE
107-15-3	5/14/96	ETHYLENEDIAMINE
69409-94-5	5/14/96	FLUVALINATE*
50-00-0	7/11/96	FORMALDEHYDE*
111-30-8	7/11/96	GLUTARALDEHYDE
5051-62-7	2/1/96	GUANABENZ
354-23-4	6/7/96	HCFC-123a *
812-04-4	6/7/96	HCFC-123b*
354-25-6	6/7/96	HCFC-124a*
9005-49-6	5/11/96	HEPARIN
757-58-4	1/19/96	HEXAETHYLTETRAPHOSPHATE
822-06-0	5/17/96	HEXAMETHYLENE DIISOCYANATE*
53-86-1	1/26/96	INDOMETHACIN
4098-71-9	6/3/96	ISOPHORONE DIISOCYANATE*
16853-85-3	5/10/96	LITHIUM ALUMINUM HYDRIDE
108-31-6	6/3/96	MALEIC ANHYDRIDE*
1344-43-0	7/11/96	MANGANOUS OXIDE
61-68-7	1/26/96	MEFENAMIC ACID
100-97-0	1/19/96	METHENAMINE
61-32-5	7/11/96	METHICILLIN
101-68-8	6/24/96	METHYLENEBIS(4-PHENYLISOCYANATE)*
142-47-2	5/10/96	MONOSODIUM GLUTAMATE
57-27-2	7/11/96	MORPHINE
147-52-4	7/11/96	NAFCILLIN
9006-04-6	2/1/96	NATURAL RUBBER
7440-02-0	6/21/96	NICKEL*
373-02-4	6/21/96	NICKEL ACETATE*
15699-18-0	6/21/96	NICKEL AMMONIUM SULFATE*
3333-67-3	6/21/96	NICKEL CARBONATE*
7718-54-9	6/21/96	NICKEL CHLORIDE*
557-19-7	6/21/96	NICKEL CYANIDE*

Table IV.2.A-1: Chemicals Associated with Asthma in the Hazardous Substances Data Bank (HSDB) Human Toxicity Excerpts (metal compounds are assumed to have characteristics of parent element)		
CAS Number	**HSDB Entry Revision**	**Chemical name**
15843-02-4	6/21/96	NICKEL FORMATE*
12054-48-7	6/21/96	NICKEL HYDROXIDE*
13138-45-9	6/21/96	NICKEL NITRATE*
7786-81-4	6/21/96	NICKEL SULFATE*
10102-44-0	7/11/96	NITROGEN DIOXIDE*
95-54-5	6/6/96	O-PHENYLENEDIAMINE
20816-12-0	6/6/96	OSMIUM TETROXIDE*
79-57-2	1/26/96	OXYTETRACYCLINE
101-54-2	1/23/96	P-AMINODIPHENYLAMINE
51-78-5	1/23/96	P-AMINOPHENOL HYDROCHLORIDE
61-33-6	7/11/96	PENICILLIN G
87-08-1	7/11/96	PENICILLIN V
132-98-9	7/11/96	PENICILLIN VK
354-33-6	2/1/96	PENTAFLUOROETHANE
53910-25-1	2/1/96	PENTOSTATIN
132-93-4	7/11/96	PHENETHICILLIN POTASSIUM
50-33-9	1/26/96	PHENYLBUTAZONE
85-44-9	6/24/96	PHTHALIC ANHYDRIDE*
110-85-0	1/21/96	PIPERAZINE
142-64-3	6/6/96	PIPERAZINE HYDROCHLORIDE
51-03-6	6/6/96	PIPERONYL BUTOXIDE*
10025-65-7	5/14/96	PLATINOUS CHLORIDE
7440-06-4	6/6/96	PLATINUM
13454-96-1	6/6/96	PLATINUM TETRACHLORIDE
50-24-8	1/26/96	PREDNISOLONE
121-21-1	5/14/96	PYRETHRIN I
121-29-9	5/14/96	PYRETHRIN II
8003-34-7	6/24/96	PYRETHRUM
50-54-4	5/14/96	QUINIDINE SULFATE
130-95-0	6/6/96	QUININE
36791-04-5	2/1/96	RIBAVIRIN
9009-86-3	1/27/96	RICIN
1302-42-7	6/21/96	SODIUM ALUMINATE
13770-96-2	5/10/96	SODIUM ALUMINUM HYDRIDE
7785-88-8	5/10/96	SODIUM ALUMINUM PHOSPHATE
7631-90-5	7/11/96	SODIUM BISULFITE
7681-57-4	7/11/96	SODIUM METABISULFITE
1344-06-5	5/10/96	SODIUM PHOSPHOALUMINATE
9000-36-6	1/21/96	STERCULIA GUM
17784-12-2	1/26/96	SULFACYTINE
7704-34-9	1/28/96	SULFUR
7446-09-5	6/11/96	SULFUR DIOXIDE
115-44-6	1/26/96	TALBUTAL

Table IV.2.A-1: Chemicals Associated with Asthma in the Hazardous Substances Data Bank (HSDB) Human Toxicity Excerpts (metal compounds are assumed to have characteristics of parent element)		
CAS Number	**HSDB Entry Revision**	**Chemical name**
117-08-8	1/26/96	TETRACHLOROPHTHALIC ANHYDRIDE
26839-75-8	2/1/96	TIMOLOL
26471-62-5	5/14/96	TOLUENE DIISOCYANATE*
95-80-7	7/22/96	TOLUENE-2,4-DIAMINE
25376-45-8	1/31/96	TOLUENE-AR,AR'-DIAMINE
9000-65-1	1/23/96	TRAGACANTH GUM
14913-33-8	5/13/96	TRANS-DIAMMINEDICHLOROPLATINUM
75-69-4	6/11/96	TRICHLOROFLUOROMETHANE*
84-96-8		TRIMEPRAZINE
12035-72-2	6/21/96	TRINICKEL DISULFIDE
1314-62-1	6/11/96	VANADIUM PENTOXIDE
[1]Compounds of the metals are assumed to fall under the category of compounds listed in TRI.		

APPENDIX IV.2-B. DRUG THERAPIES RECOMMENDED BY NHLBI

Tables IV.2.B-1, IV.2.B-2, IV.2.B-3, and IV.2.B-4 in this appendix list the drug therapies recommended by NHLBI for adults and children. The tables were copied directly from the NHLBI guidelines website:

http://www.nhlbi.nih.gov/index.htm

Link to guidelines

A number of alternative therapies are listed for most situations (e.g., long-term control, quick relief). Data were not available on the distribution of drugs used among asthma patients. To facilitate calculation of costs, a single drug for each type of therapy was selected for most situations, based on those that were most commonly referenced in the literature. The exception to this is the long term control medications. While inhaled corticosteroids are often prescribed for older patients, most children are initially prescribed cromolyn or nedocromil, so costs of the two different groups of medications were considered for the two different age groups. The drug therapy used to calculate costs is shown in italics in the tables that follow. In practice, physicians may choose any of the alternative drug therapies, depending on the specific characteristics of the medication and the patient.

The dosages specified in these tables were used to calculate the annual drug usages and costs. When a range of doses is presented in the tables (e.g., for methylprednisolone) the midpoint of the range was used to estimate the average dose. The alternative drug therapies are provided in this appendix so that the reader can evaluate different alternatives if they wish.

Table IV.2-B-1: Usual Dosages For Long-term-control Medications*				
Medication	**Dosage Form**	**Adult Dose**	**Child Dose**	**Comments**
Inhaled Corticosteroids (see Tables IV.2.B-2 and IV.2.B-3)				
Systemic Corticosteroids (Applies to all three systemic corticosteroids)				
Methylprednisolone Prednisolone Prednisone	*2, 4, 8, 16, 32 mg tablets* 5mg tablets, 5mg/5 cc, 15mg/5 cc 1, 2.5, 5, 10, 20, 25 mg tablets; 5 mg/cc, 5mg/5 cc	• *7.5–60 mg daily in a single dose or qid as needed for control* • Short-course "burst": 40–60 mg per day as single or 2 divided doses for 3–10 days	• *0.25–2 mg/kg daily in single dose or qid as needed for control* • Short course "burst": 1–2 mg/kg/day, maximum 60 mg/day, for 3–10 days	• For long-term treatment of severe persistent asthma, administer single dose in a.m. either daily or on alternate days (alternate-day therapy may produce less adrenal suppression). If daily doses are required, one study suggests improved efficacy and no increase in adrenal suppression when administered at 3:00 p.m. (Beam et al. 1992). • Short courses or "bursts" are effective for establishing control when initiating therapy or during a period of gradual deterioration. • The burst should be continued until patient achieves 80% PEF personal best or symptoms resolve. This usually requires 3-10 days but may require longer treatment. There is no evidence that tapering the dose following improvement prevents relapse.

Table IV.2-B-1: Usual Dosages For Long-term-control Medications*				
Medication	**Dosage Form**	**Adult Dose**	**Child Dose**	**Comments**
Cromolyn and Nedocromyl				
Cromolyn	*MDI 1 mg/puff* *Nebulizer solution* *20 mg/ampule*	*2–4 puffs tid-qid* *1 ampule tid-qid*	*1–2 puffs tid-qid* *1 ampule tid-qid*	• *One dose prior to exercise or allergen exposure provides effective prophylaxis for 1–2 hours.*
Nedocromil	MDI 1.75 mg/puff	2–4 puffs bid-qid	1–2 puffs bid-qid	• See cromolyn above.
Long-Acting beta$_2$ Agonists				
Salmeterol	Inhaled MDI 21 mcg/puff, 60 or 120 puffs DPI 50 mcg/ blister	2 puffs q 12 hours 1 blister q 12 hours	1–2 puffs q 12 hours 1 blister q 12 hours	• May use one dose nightly for symptoms. • Should not be used for symptom relief or for exacerbations.
Sustained-Release Albuterol	Tablet 4 mg tablet	4 mg q 12 hours	0.3–0.6 mg/kg/day, not to exceed 8 mg/day	
Methylxanthines				
Theophylline	Liquids, sustained-release tablets, and capsules	Starting dose 10 mg/kg/day up to 300 mg max; usual max 800 mg/day	Starting dose 10 mg/kg/day; usual max: • <1 year of age: 0.2 (age in weeks) + 5 = mg/kg/day • ≥1 year of age: 16 mg/kg/day	• Adjust dosage to achieve serum concentration of 5–15 mcg/mL at steady-state (at least 48 hours on same dosage). • Due to wide interpatient variability in theophylline metabolic clearance, routine serum theophylline level monitoring is important. • See factors on page 87 that can affect levels.

Table IV.2-B-1: Usual Dosages For Long-term-control Medications*				
Medication	**Dosage Form**	**Adult Dose**	**Child Dose**	**Comments**
Leukotriene Modifiers				
Zafirlukast	20 mg tablet	40 mg daily (1 tablet bid)		• For zafirlukast, administration with meals decreases bioavailability; take at least 1 hour before or 2 hours after meals.
Zileuton	300 mg tablet 600 mg tablet	2,400 mg daily (two 300 mg tablets or one 600 mg tablet, qid)		• For zileuton, monitor hepatic enzymes (ALT).
* q indicates “every”, bid indicates “twice a day,” tid indicates “three times a day,” qid indicates “four times a day.”				

Table IV.2.B-2: Estimated Comparative Daily Dosages For Inhaled Corticosteroids			
Drug	**Low Dose**	**Medium Dose**	**High Dose**
Adults			
Beclomethasone dipropionate *42 mcg/puff* *84 mcg/puff*	*168-504 mcg* *(4-12 puffs — 42 mcg)* *(2-6 puffs — 84 mcg)*	*504-840 mcg* *(12-20 puffs — 42 mcg)* *(6-10 puffs — 84 mcg)*	*>840 mcg* *(>20 puffs — 42 mcg)* *(>10 puffs — 84 mcg)*
Budesonide DPI: 200 mcg/dose	200-400 mcg (1-2 inhalations)	400-600 mcg (2-3 inhalations)	>600 mcg (>3 inhalations)
Flunisolide 250 mcg/puff	500-1,000 mcg (2-4 puffs)	1,000-2,000 mcg (4-8 puffs)	>2,000 mcg (>8 puffs)
Fluticasone MDI: 44, 110, 220 mcg/puff DPI: 50, 100, 250 mcg/dose	88-264 mcg (2-6 puffs — 44 mcg) OR (2 puffs — 110 mcg) (2-6 inhalations — 50 mcg)	264-660 mcg (2-6 puffs — 110 mcg) (3-6 inhalations — 100 mcg)	>660 mcg (>6 puffs — 110 mcg) OR (>3 puffs — 220 mcg) (>6 inhalations — 100 mcg) OR (>2 inhalations — 250 mcg)
Triamcinolone acetonide 100 mcg/puff	400-1,000 mcg (4-10 puffs)	1,000-2,000 mcg (10-20 puffs)	>2,000 mcg (>20 puffs)
Children			
Beclomethasone dipropionate *42 mcg/puff* *84 mcg/puff*	*84-336 mcg* *(2-8 puffs — 42 mcg)* *(1-4 puffs — 84 mcg)*	*336-672 mcg* *(8-16 puffs — 42 mcg)* *(4-8 puffs — 84 mcg)*	*>672 mcg* *(>16 puffs — 42 mcg)* *(>8 puffs — 84 mcg)*
Budesonide DPI: 200 mcg/dose	100-200 mcg	200-400 mcg (1-2 inhalations — 200 mcg)	>400 mcg (>2 inhalations — 200 mcg)
Flunisolide 250 mcg/puff	500-750 mcg (2-3 puffs)	1,000-1,250 mcg (4-5 puffs)	>1,250 mcg (>5 puffs)
Fluticasone MDI: 44, 110, 220 mcg/puff DPI: 50, 100, 250 mcg/dose	88-176 mcg (2-4 puffs — 44 mcg) (2-4 inhalations — 50 mcg)	176-440 mcg (4-10 puffs — 44 mcg) OR (2-4 puffs — 110 mcg) (2-4 inhalations — 100 mcg)	>440 mcg (>4 puffs — 110 mcg) OR (>2 puffs — 220 mcg) (>4 inhalations — 100 mcg) OR (>2 inhalations — 250 mcg)
Triamcinolone acetonide 100 mcg/puff	400-800 mcg (4-8 puffs)	800-1,200 mcg (8-12 puffs)	>1,200 mcg (>12 puffs)

Table IV.2.B-3: Usual Dosages for Quick-relief Medications*				
Medication	**Dosage Form**	**Adult Dose**	**Child Dose**	**Comments**
Short-Acting Inhaled Beta$_2$ -Agonists				
	MDI			
Albuterol Albuterol HFA Bitolterol Pirbuterol Terbutaline	*90 mcg/puff, 200 puffs* 90 mcg/puff, 200 puffs 370 mcg/puff, 300 puffs 200 mcg/puff, 400 puffs 200 mcg/puff, 300 puffs	•2 puffs 5 minutes prior to exercise •2 puffs tid-qid prn	• 1-2 puffs 5 minutes prior to exercise • 2 puffs tid-qid prn	•An increasing use or lack of expected effect indicates diminished control of asthma. •Not generally recommended for long-term treatment. Regular use on a daily basis indicates the need for additional long-term-control therapy. •Differences in potency exist so that all products are essentially equipotent on a per puff basis. •May double usual dose for mild exacerbations. •Nonselective agents (i.e., epinephrine, isoproterenol, etaproterenol) are not recommended due to their potential for excessive cardiac stimulation, especially in high doses.
	DPI			
Albuterol Rotahaler	200 mcg/capsule	1-2 capsules 4-6 hours as needed and prior to exercise	1 capsule 4-6 hours as needed and prior to exercise	
Albuterol	Nebulizer solution 5 mg/mL (0.5%)	1.25-5 mg (.25-1 cc) in 2-3 cc of saline q 4-8 hours	0.05 mg/kg (min 1.25 mg, max 2.5 mg) in 2-3 cc of saline q 4-6 hours	May mix with cromolyn or ipratropium nebulizer solutions. May double dose for mild exacerbations.
Bitolterol	2 mg/mL (0.2%)	0.5-3.5mg (.25-1 cc) in 2-3 cc of saline q 4-8 hours	Not established	May not mix with other nebulizer solutions.
Anticholinergics				
	MDI			
Ipratropium	18 mcg/puff, 200 puffs Nebulizer solution .25 mg/mL (0.025%)	2-3 puffs q 6 hours 0.25 mg q 6 hours	1-2 puffs q 6 hours 0.25-0.5 mg q 6 hours	Evidence is lacking for anticholinergics producing added benefit to beta$_2$ -agonists in long-term asthma therapy.

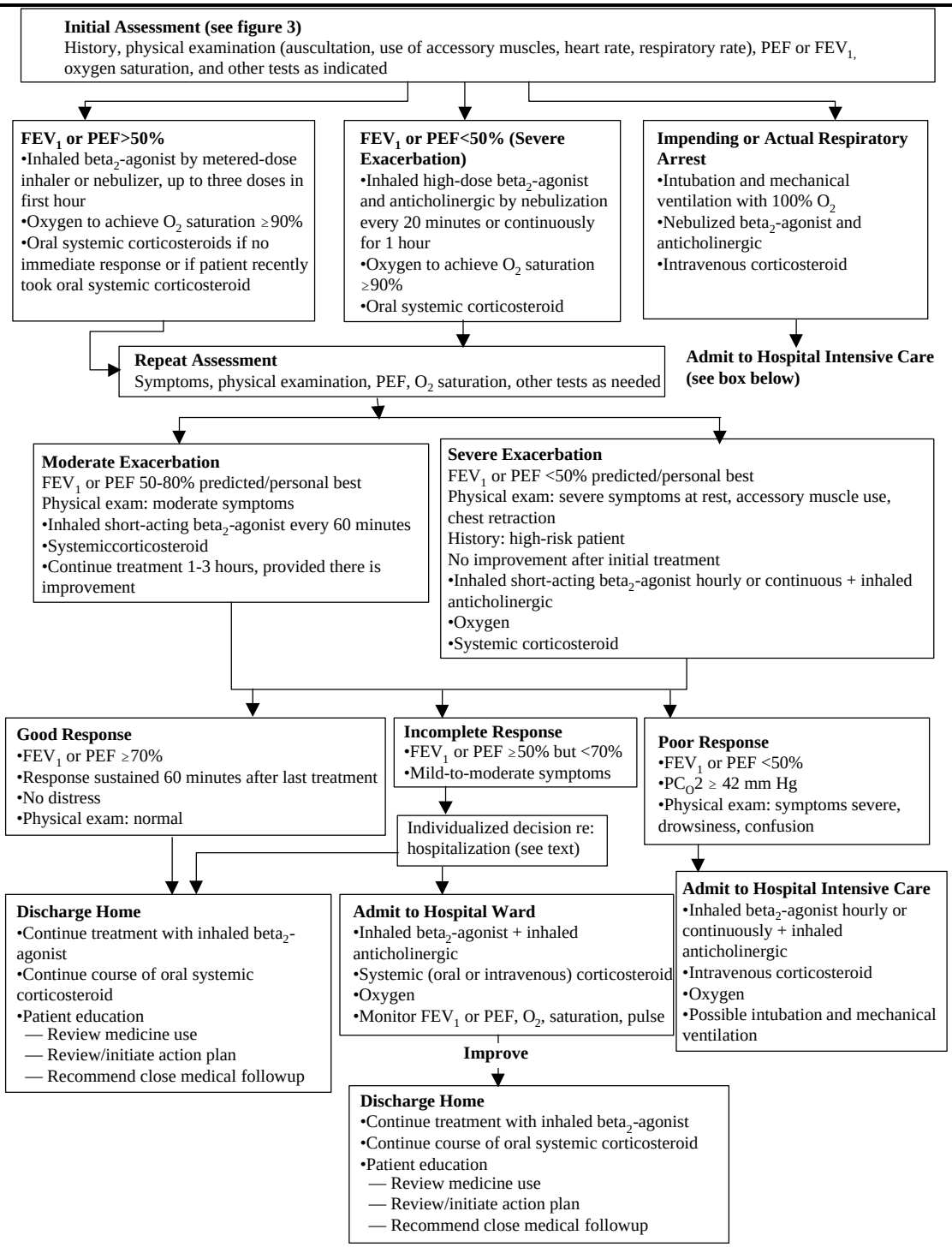
Table IV.2.B-3: Usual Dosages for Quick-relief Medications*				
Medication	**Dosage Form**	**Adult Dose**	**Child Dose**	**Comments**
Systemic Corticosteroids (Applies to all three systemic corticosteroids)				
Methylpred-nisolone Prednis-olone Prednisone	2, 4, 8, 16, 32 mg tablets 5 mg tabs, 5 mg/5 cc, 15 mg/5 cc 1, 2.5, 5, 10, 20, 25 mg tabs; 5 mg/cc, 5 mg/5 cc	•Short course "burst": 40-60 mg/day as single or 2 divided doses for 3-10 days	•Short course "burst": 1-2 mg/kg/day, maximum 60 mg/day, for 3-10 days	•Short courses or "bursts" are effective for establishing control when initiating therapy or during a period of gradual deterioration. •The burst should be continued until patient achieves 80% PEF personal best or symptoms resolve. This usually requires 3-10 days but may require longer treatment. There is no evidence that tapering the dose following improvement prevents relapse.
* "tid qid prn" indicates three to four times per day, according to circumstances; "q" indicates "every."				

Table IV.2.B-4: Dosages of Drugs for Asthma Exacerbations in Emergency Medical Care or Hospital			
	Dosages		
Medication	**Adult Dose**	**Child Dose**	**Comments**
Inhaled Short-Acting Inhaled Beta$_2$ -Agonists			
Albuterol Nebulizer solution (5 mg/mL)	2.5-5 mg every 20 minutes for 3 doses, then 2.5-10 mg every 1-4 hours as needed, or 10-15 mg/hour continuously	0.15 mg/kg (minimum dose 2.5 mg) every 20 minutes for 3 doses, then 0.15-0.3 mg/kg up to 10 mg every 1-4 hours as needed, or 0.5 mg/kg/hour by continuous nebulization	Only selective beta$_2$-agonists are recommended. For optimal delivery, dilute aerosols to minimum of 4 mL at gas flow of 6-8 l/min.
MDI (90 mcg/puff)	4-8 puffs every 20 minutes up to 4 hours, then every 1-4 hours as needed	4-8 puffs every 20 minutes for 3 doses, then every 1-4 hours inhalation maneuver. Use spacer/holding chamber.	As effective as nebulized therapy if patient is able to coordinate
Bitolterol Nebulizer solution (2 mg/mL)	See albuterol dose	See albuterol dose; thought to be half as potent as albuterol on a mg basis	Has not been studied in severe asthma exacerbations. Do not mix with other drugs.
MDI (370 mcg/puff)	See albuterol dose	See albuterol dose	Has not been studied in severe asthma exacerbations.
MDI (200 mcg/puff)	See albuterol dose	See albuterol dose; thought to be half as potent as albuterol on a mg basis	Has not been studied in severe asthma exacerbations.
Systemic (Injected) Beta$_2$ -Agonists			
Epinephrine 1:1000 (1 mg/mL)	0.3-0.5 mg every 20 minutes for 3 doses sq	0.01 mg/kg up to 0.3-0.5 mg every 20 minutes for 3 doses sq	No proven advantage of systemic therapy over aerosol.
Terbutaline (1 mg/mL)	0.25 mg every 20 minutes for 3 doses sq	0.01 mg/kg every 20 minutes for 3 doses then every 2-6 hours as needed sq	No proven advantage of systemic therapy over aerosol.
Anticholinergics			
Ipratropium bromide Nebulizer solution (.25 mg/mL)	0.5 mg every 30 minutes for 3 doses then every 2-4 hours as needed	.25 mg every 20 minutes for 3 doses, then every 2 to 4 hours	May mix in same nebulizer with albuterol. Should not be used as first-line therapy; should be added to beta$_2$-agonist therapy.
MDI (18 mcg/puff)	4-8 puffs as needed	4-8 puffs as needed	Dose delivered from MDI is low and has not been studied in asthma exacerbations.
Corticosteroids			

Table IV.2.B-4: Dosages of Drugs for Asthma Exacerbations in Emergency Medical Care or Hospital			
	Dosages		
Medication	**Adult Dose**	**Child Dose**	**Comments**
Prednisone Methylprednisolone Prednisolone	120-180 mg/day in 3 or 4 divided doses for 48 hours, then 60-80 mg/day until PEF reaches 70% of predicted or personal best	1 mg/kg every 6 hours for 48 hours then 1-2 mg/kg/day (maximum = 60 mg/day) in 2 divided doses until PEF 70% of predicted or personal best	For outpatient “burst” use 40-60 mg in single or 2 divided doses for adults (children: 1-2 mg/kg/day, maximum 60 mg/day) for 3-10 days

Note:
- No advantage has been found for higher dose corticosteroids in severe asthma exacerbations, nor is there any advantage for intravenous administration over oral therapy provided gastrointestinal transit time or absorption is not impaired. The usual regimen is to continue the frequent multiple daily dosing until the patient achieves an FEV 1 or PEF of 50 percent of predicted or personal best and then lower the dose to twice daily. This usually occurs within 48 hours. Therapy following a hospitalization or emergency department visit may last from 3 to 10 days. If patients are then started on inhaled corticosteroids, studies indicate there is no need to taper the systemic corticosteroid dose. If the follow-up systemic corticosteroid therapy is to be given once daily, one study indicates that it may be more clinically effective to give the dose in the afternoon at 3:00 p.m., with no increase in adrenal suppression (Beam et al., 1992).

Figure IV.2.B-1: Management of Asthma Exacerbations: Home Treatment



Note:
Patients at high risk of asthma-related death (see table IV.2.B-4) should receive immediate attention clinical attention after initial treatment.
Additional therapy may be required.

Table IV.2.B-5: Hospital Discharge Checklist for Patients with Asthma Exacerbations			
Intervention	**Dose/Timing**	**Education/Advice**	**M.D./R.N. Initials**
Inhaled medication (MDI + spacer/holding chamber) $Beta_2$-agonist Corticosteroids	Select agent, dose, and frequency (e.g., albuterol) 2-6 puffs q 3-4 hr prn Medium dose	Teach purpose Teach technique Emphasize need for spacer/holding chamber Check patient technique	
Oral medications	Select agent, dose, and frequency (e.g., prednisone 20 mg bid for 3-10 days)	Teach purpose Teach side effects	
Peak flow meter	Measure a.m. and p.m. PEF and record best of three tries each time.	Teach purpose Teach technique Distribute peak flow diary	
Follow-up visit	Make appointment for follow-up care with primary clinician or asthma specialist	Advise patient (or caregiver) of date, time, and location of appointment within 7 days of hospital discharge	
Action plan	Before or at discharge	Instruct patient (or caregiver) on simple plan for actions to be taken when symptoms, signs, and PEF values suggest recurrent airflow obstruction	
q indicates “every,” prn indicates “according to circumstances.”			